FINAL TECHNICAL REPORT

"DENSE MEDIUM CYCLONE OPTIMIZATION"

Project Period:

December 14, 2000 – December 30, 2004

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Report Issue Date:

June 30, 2005

DOE Award Number:

DE-FC26-01NT41061

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ABSTRACT

Dense medium cyclones (DMCs) are known to be efficient, high-tonnage devices suitable for upgrading particles in the 50 to 0.5 mm size range. This versatile separator, which uses centrifugal forces to enhance the separation of fine particles that cannot be upgraded in static dense medium separators, can be found in most modern coal plants and in a variety of mineral plants treating iron ore, dolomite, diamonds, potash and lead-zinc ores. Due to the high tonnage, a small increase in DMC efficiency can have a large impact on plant profitability. Unfortunately, the knowledge base required to properly design and operate DMCs has been seriously eroded during the past several decades. In an attempt to correct this problem, a set of engineering tools have been developed to allow producers to improve the efficiency of their DMC circuits. These tools include (i) low-cost density tracers that can be used by plant operators to rapidly assess DMC performance, (ii) mathematical process models that can be used to predict the influence of changes in operating and design variables on DMC performance, and (iii) an expert advisor system that provides plant operators with a user-friendly interface for evaluating, optimizing and trouble-shooting DMC circuits. The field data required to develop these tools was collected by conducting detailed sampling and evaluation programs at several industrial plant sites. These data were used to demonstrate the technical, economic and environmental benefits that can be realized through the application of these engineering tools.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

1.1 <u>Background</u>

For nearly 50 years, dense medium cyclones (DMCs) have been used by the mining industry to upgrade relatively coarse particles in the 50 to 0.5 mm size range. These high-capacity units, which are often operated in parallel banks (see Figure 1.1), utilize centrifugal forces to enhance the separation of fine particles that cannot be efficiently upgraded using static density-based separators such as dense medium vessels and baths. DMCs are relatively inexpensive and typically require little operator attention. Consequently, DMC circuits have grown in popularity to the point where they are now used in a variety of mineral beneficiation and coal processing plants. In the U.S. alone, DMCs are used in nearly 80% of all coal plants, representing an installed capacity in excess of 85,000 tons/hr. Estimates suggest that a very seemingly insignificant one percentage point increase in the DMC efficiency would produce 1.6 million tons of additional clean coal in the U.S. from the same tonnage of mined coal. At a price of $38/ton (current spot-market value), the recovered tonnage represents annual revenues of nearly $60 million for the U.S. coal industry. Therefore, a small improvement in the efficiency of DMCs can greatly enhance industry profitability.

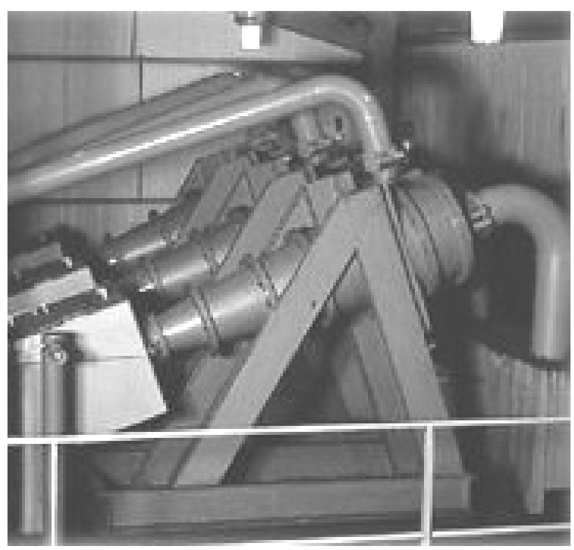

Figure 1.1. A triple bank of DMCs (courtesy of Krebs Engineers).

Most of the early expertise related to the design and operation of DMC circuits was developed by researchers at the Dutch State Mines in the 1940s and 50s. This renowned group developed a large body of test data which, for commercial reasons, was never freely published. One of their best works was a proprietary technical manual for DMC circuit design that was only provided to their licensees. Although this manual served the industry well, it was thought to suffer from several major shortcomings. For example, the manual was developed as a guide for the "design" of DMC circuits, i.e., the manual provides recommendations for cyclone geometry, inlet pressure, feed medium density, magnetite fineness, etc., required to achieve a given throughput and cutpoint. The manual is, in essence, a statement of good operating practice. However, the manual provides no indication of how sensitive the separation is to variations in operating parameters. Therefore, plant operators are often unaware of the impacts that normal variations in operating pressure (due to pump wear) or circulating medium (due to losses of ultrafine magnetite in the magnetic recovery circuit) may have on DMC performance. Another major shortcoming of the manual is that it primarily focuses on installations treating fine (<15 mm) coal. Although the manual mentions operational problems that can occur when treating coarser particles, it offers no guidance as to how these problems may be identified or resolved. Technical issues regarding the application of DMC circuits for non-coal (mineral) applications are also largely ignored. Many of these items may have been studied by the pioneering researchers at Dutch State Mines, but their data were never freely published and were lost when this group ceased operations in the late 1960s.

Several noteworthy studies have been published regarding the design and operation of DMC circuits since the demise of the Dutch State Mines. Significant works include the research conducted at the U.S. Bureau of Mines by Gottfried and Jacobsen

(1977) which helped to provide a convenient means of representing size-by-size partition curves for DMCs. However, reports describing this work give little detail on the operating conditions used in the study. Several good performance models for DMCs were developed during the 1980s by Napier-Munn (1984), Rao et al. (1986), Davis (1987), King and Juckes (1988) and Scott (1988). However, none of these early works was able to directly link the independent design and operating variables (geometry, inlet pressure, magnetite grind, etc.) to dependent variables such as specific gravity (SG) cutpoint or Ecart probable (Ep). Several significant studies were also performed by Chedgy et al. (1988) and Restarick and Krnic (1990), but these investigations primarily addressed issues related to difficulties in making low density separations. Consequently, the engineering knowledge required to properly design and operate DMC circuits remained largely incomplete.

Since the late 1980s, researchers in Australia have carried out R&D programs to address the lack of engineering criteria for DMC design and operation. Much of this expertise can be attributed to the work of Dr. Chris Wood while employed at the Julius Kruttschnitt Minerals Research Centre (JKMRC) in Brisbane. In conjunction with other JKMRC researchers, Wood developed a variety of advanced mathematical models, simulation programs and user handbooks for the design, evaluation and optimization of DMC circuits. Much of the pioneering work associated with the use of density tracers for evaluating DMC performance was performed by these researchers. Through their field studies, these workers documented yield losses of as much as 15% due to problems with DMC circuits. The most common problems encountered included parallel units separating at different densities and vortex finder overload or surging due to temporary accumulation of middlings. In many cases, these problems were corrected by low-cost modifications to plant circuitry or operating procedures.

The work at JKMRC demonstrates the tremendous benefits that may be realized through improvements in DMC operation. For example, a JKMRC study conducted at the Riverside plant, Australia, indicated that the DMC circuits in one half of the plant separated density tracers at 0.05 SG units higher than did those in the other half. The problem was identified as a poor application of nucleonic density gauges and inadequate mixing of return medium. By correcting these problems, the cutpoints were properly matched and the resulting yield improvement generated additional annual revenues in excess of $1 million. At several other operations, the DMC plants were found to suffer from severe yield loss due to inappropriate medium rheology. At one site, for example, it was found that excessive particle retention (causing surging and yield loss) could be avoided by rearrangement of the way in which correct density medium was bled to the regeneration circuit. The result of this action was to increase revenue by an estimated $2 million annually. Corresponding modifications have now been made by the parent company in two of their other preparation plants.

The engineering expertise developed through the efforts of Wood and others at JKMRC has been summarized in a proprietary handbook entitled "*Coal Washing Dense Medium Cyclones*." Unfortunately, the use of this handbook is restricted to the Australian companies who sponsored the research through the Australian Mineral Industries Research Association (AMIRA). As such, much of this expertise is not available to U.S. producers. In light of this problem, the intent of this project has been the development of a set of engineering tools that can be used to translate the DMC expertise developed in Australia to the U.S. situation.

The potential economic impacts of improvements in DMC operation and design for the U.S. coal industry can be best illustrated by means of an example. Figure 1.2 shows a situation that is considered typical for modern coal plants. As shown, the highest DMC yield for a particular feed is achieved by a hypothetical device that sorts particles individually according to quality (i.e., ash content). The performance of a properly operated float-sink laboratory is only slightly worse than the ideal separation. A typical DMC plant operating at a high SG cutpoint approaches the ideal curve; however, at the lower SGs required to generate higher product qualities (i.e., moderate to low ash products), yield from a typical plant falls well below the ideal separation. Current estimates (Wood et al., 1997) suggest that only one-fourth of the discrepancy between the actual and ideal separation curves can be eliminated by technological improvements in equipment design. On the other hand, three-fourths of this discrepancy can be eliminated by ensuring that existing dense medium separators work at peak efficiency. While it may be impractical to routinely maintain this level of performance, preliminary work suggests that about half of this improvement can be consistently achieved at industrial sites. If the coal sample used in this illustration were washed to an ash of 7.5%, the achievable yield increase would be more than three percent. This improvement can often be realized at minimal cost through minor alterations in circuit layout or maintenance procedures. For a U.S. plant treating 500 tph of raw coal in the dense medium cyclone circuit, this improvement would amount to more than $4.5 million of additional saleable clean coal per year (i.e., 3% x 500 ton/hr x $50/ton x 6,000 hr/yr = $4.5 MM/yr). Therefore, a good

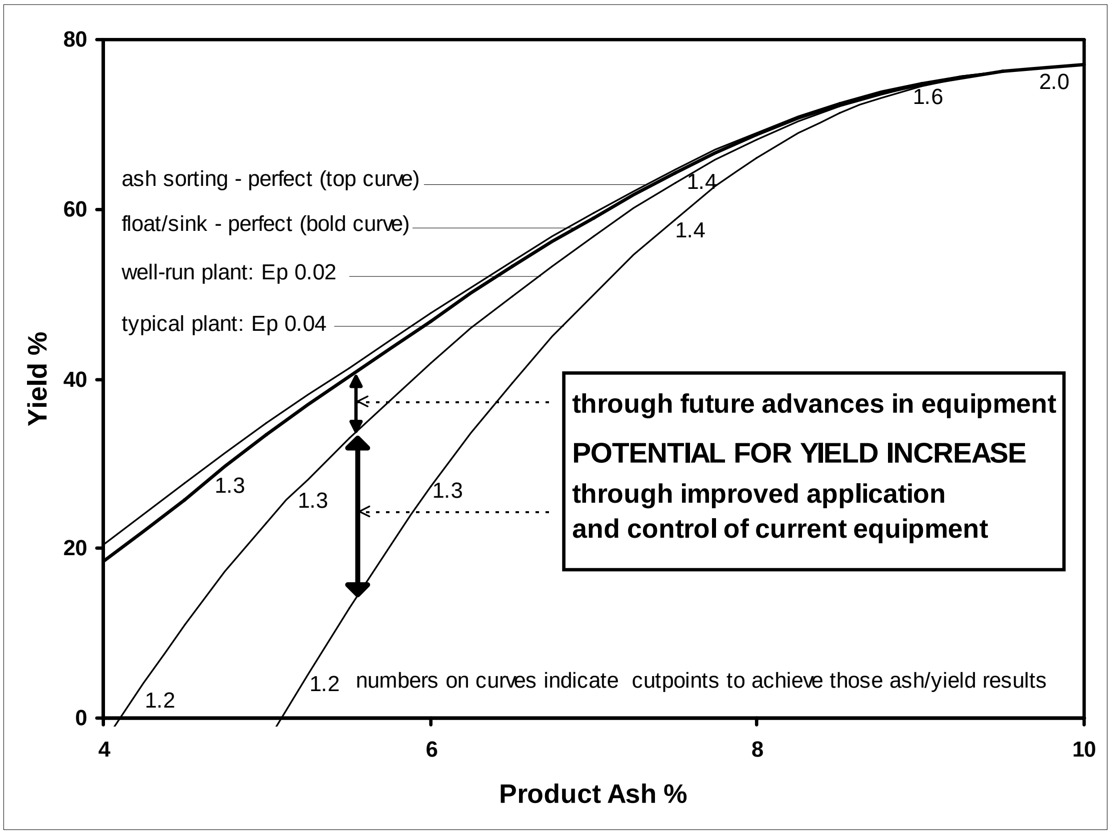

Figure 1.2. Yield increases expected through (i) future advances in equipment design and (ii) improved application and control of current equipment (after Wood, 1997).

return on investment can be expected for the development of engineering tools that allow plant operators to evaluate and optimize the performance of existing equipment.

1.2 Common DMC Problems

Field studies indicate that the most common troubles encountered in dense medium cyclone circuits include:

- clean coal overload,
- excessive particle retention,
- and incorrect SG cutpoints.

These problems typically result in the loss of recoverable clean coal to the refuse stream. Fortunately, these problems can often be corrected via simple low-cost modifications to plant circuitry or changes to plant operating protocols.

1.2.1 Clean Coal Vortex Overload

The vortex finder of a dense medium cyclone is somewhat analogous to the overflow lip of a dense medium vessel. In a vessel, a minimum depth of overflow of 7-10 cm must be maintained to ensure that the largest size particles of clean coal can be hydraulically carried into the clean product. Likewise, an adequate flow of medium containing the proper amount of medium particles must pass through the vortex finder of a DMC in order to carry out the coal particles. If the flow of medium to the overflow is too low, then the excess clean coal cannot be carried through the vortex finder and will instead report to refuse. This problem is common in DMCs operated with too large an apex or too low of an inlet pressure.

1.2.2 Particle Retention/Surging

The centrifugal field within a DMC causes magnetite to classify and preferentially report to underflow. The classification causes the underflow SG to be higher than that of the feed and the overflow SG to be lower than that of the feed. As a result, middlings particles that have a density between that of the feed SG and overflow SG tend to remain in the cyclone for a longer period of time than particles outside this density range. Retention is normally associated with only the coarsest particles and rarely occurs for particles finer than about 15 mm. The retention of coarser middlings may even improve the separation by breaking middlings into smaller particles that are better liberated and easier to discharge. However, particle retention can be a serious problem when middlings particles enter the cyclone at a faster rate than they can be removed. The excessive build-up of middlings eventually leads to a sudden surge to the underflow that clears the accumulated load of retained material. Unfortunately, the surge also tends to carry out a portion of low-density clean coal to the refuse stream.

1.2.3 Improper Specific Gravity Cutpoints

Dense medium cyclones are frequently installed in banks of two or more parallel units in order to achieve the production requirements of a given plant. For all practical purposes, the maximum yield from such a circuit can only be achieved when all of the DMCs are operated at the same specific gravity cutpoints. This optimization principle is valid regardless of the desired quality of the total clean coal product or the ratios of different coals passed through the circuit (Abbott, 1981; Luttrell et al., 2000).

To illustrate the importance of optimizing DMC circuits, consider a 500-tph circuit consisting of two identical DMCs. Both cyclones are capable of producing a product with an ash content of 8% when they operate at the same cutpoint of 1.51 SG. The overall yield from these two DMCs is 73.4%. However, the two units can also produce a combined clean coal ash of 8% by operating the first cyclone at 1.56 SG (which produces 8.5% ash) and by operating the second cyclone at 1.46 SG (which produces 7.5% ash). Although the combined product is still 8% ash, operation at a cutpoint difference of 0.1 SG units reduces the overall plant yield from 73.4% to 73.1%. If the cyclones are operated for 5000 hrs per year, the annual revenue lost due to improper optimization is $225,000 (0.3% x 500 ton/hr x 5000 hr/yr x $30/ton = $225,000). As shown in Figure 1.3, the loss of revenue becomes significantly greater as the quality of the clean coal is reduced from 8% ash to 6% ash. At the 6% ash value, a cutpoint difference of just 0.04 SG units between the two DMCs will result in lost revenues approaching $1 million annually for the washability data and coal market values employed in this particular example. Thus, it is important that all dense medium circuits (vessels and cyclones) be operated at the same SG cutpoint to optimize total plant yield.

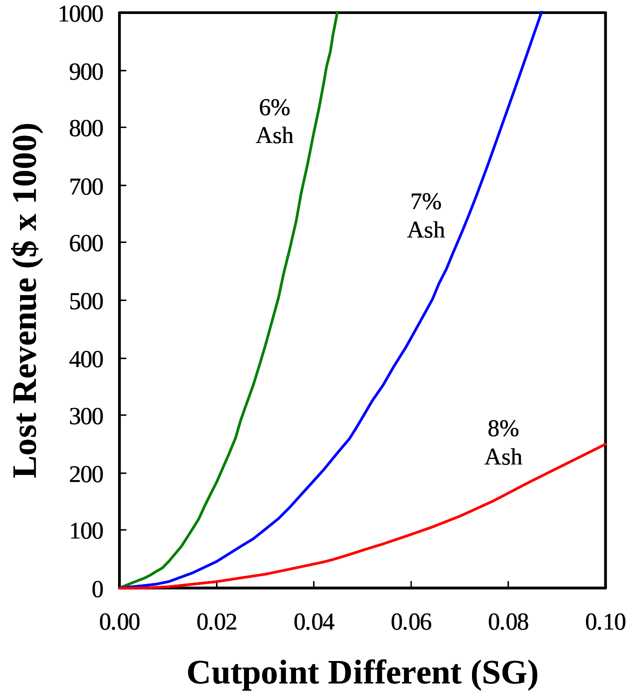

Figure 1.3. Lost revenue due to different cutpoints for a bank of twin DMCs producing clean coal ash contents of 6%, 7% and 8%.

1.3 Project Objectives

The full capabilities of DMC circuits are often not realized in industrial practice due to a shortage of properly trained operators and a lack of accepted guidelines for design and operation. Therefore, the objective of this project was to develop a set of engineering tools that can be used to improve the efficiency of DMC circuits. These tools include:

- low-cost *density tracers* that can be used to rapidly assess DMC performance,
- a mathematical *process model* that can be used to predict the influence of changes in operating and design variables on DMC performance, and

- an *expert advisor system* containing a user-friendly interface that can be used by plant operators for evaluating, optimizing and trouble-shooting DMC circuits.

To achieve these objectives, an experimental evaluation of DMC circuits was conducted at several industrial sites in Kentucky, Virginia and West Virginia to obtain data relevant to U.S. plant practices. These data have been combined with the existing expertise of the project investigators to formulate a DMC process model and expert system. This effort continues to build on the successful DMC research by Dr. Chris Wood, a principal team member of this project. The project also offered educational opportunities and field experiences for two mining engineering students at Virginia Tech and technical training for numerous plant personnel via on-site workshops and short courses. In fact, more than two dozen short courses and workshops were given to interested industry groups as a result of this R&D project.

1.4 Project Participants

1.4.1 Organizational Structure

Participants in this project included personnel from (i) the Department of Mining and Minerals Engineering at Virginia Tech, a university-based research group with extensive expertise in coal preparation; (ii) Massey Coal Services, the technical and management group for one of the nations leading producers of high-quality coal (Massey Coal); (iii) Partition Enterprises, an Australian-based research and consulting firm; and (iv) Precision Testing Laboratories, a commercial group specializing in plant sampling, analysis and evaluation.

The day-to-day management of the proposed effort was performed by the Department of Mining and Minerals Engineering (DMME) with administrative support provided by Virginia Polytechnic Institute and State University's Office of Sponsored Programs (OSP). Technical management was distributed among the various project participants, with general coordination provided by the Principal Investigators (Dr. Gerald Luttrell and Dr. Chris Wood). Because of the strong involvement in this project by Massey Coal Services, senior personnel from this company (Dr. Peter Bethell) was also actively involved in the oversight of all technical activities. Partition Enterprises and Precision Testing Laboratories provided critically needed expertise related to plant sampling. These two groups are now actively involved in commercialization activities that make use of the information gained from this project.

1.4.2 Team Member Responsibilities

Dr. Gerald Luttrell (Professor, VPI&SU) served as Principal Investigator for the project. He was primarily responsible for initial project planning, technical administration and software development. He also participated in plant sampling programs and supervised the full-time Graduate Research Assistant (GRA) assigned to this project, Mr. Chris Barbee. Dr. Chris Wood (Research Scientist, VPI&SU; Managing Director, Partition Enterprises) was responsible for co-ordinating on-site sampling campaigns and overseeing the data analysis and simulation efforts. His input related to the evaluation of test data and recommendations for improvements that were critical to the success of the project. His company also provided the density tracers used during plant evaluations.

The investigators at VPI&SU were supported by Dr. Peter Bethell, who at the time of this work was serving as the Director of Coal Preparation for Massey Coal Services in Charleston, West Virginia. Dr. Bethell served as the primary external manager and reviewer for all technical activities carried out under this project. His company provided essential funds, facilities and personnel required to complete most portions of the proposed field work. His company also provided all financing for required circuit modifications implemented in response to the findings of this project. The sample collection and analysis tasks were largely provided by Precision Testing Laboratories in Beckley, West Virginia. In addition, several technicians and administrative assistants provided by the Department of Mining and Minerals Engineering worked at various times to support the project activities.

EXPERIMENTAL

2.1 Proposed Approach

To achieve the proposed objectives, an R&D partnership was initiated (i) to conduct a baseline evaluation of industrial plant sites in the Appalachian coalfields to assess the performance of existing DMC circuits, (ii) to develop and utilize engineering tools such as density tracers and advanced process models to formulate recommendations for improving DMC performance, (iii) to modify plant circuits and/or operating practices based on the data and analyses resulting from the baseline evaluation, (iv) to conduct a post evaluation at each of the industrial sites to quantify the extent of improvement achieved, and (v) to use the extensive database collected during both the baseline and post evaluations to develop an expert system that can be used for future evaluation, simulation and optimization of DMC circuits. For management purposes, the proposed work was subdivided into nine individual tasks as described in the following section.

2.2 Project Tasks

Task 1 – Project Planning

Prior to initiation of experimental work, a *Detailed Project Work Plan* was be prepared and submitted to DOE for approval. The work plan provided a detailed description of the proposed test program, experimental procedures, analytical methods, and reporting guidelines for the implementation and completion of the proposed work.

Task 2 – Baseline Assessment

A baseline assessment was performed to establish the existing performance of the DMC circuits at each of the selected plant sites. Initially, a total of four plants (and four

DMC circuits) located in Kentucky, Virginia and West Virginia were to be evaluated as part of this investigation. However, at the urging of the industrial participant, the scope of work was modified to include one addition plant site and to substantially expand the sampling program from four to seven DMC circuits. An initial visit was made to each site to plan the sampling program and to ensure that plant personnel and facilities were prepared. During this visit, the plant was shut down for detailed assessment of the condition and dimensions of the DMCs and to ensure that at least one properly calibrated pressure gauge was fitted to the cyclones. A mock sampling campaign was conducted to identify the best locations for sample collection and to determine whether new sampling ports needed to be added. A custom set of appropriate sampling tools were also fabricated for each site for taking representative samples of the circulating medium, deslime screen oversize, cyclone overflow and cyclone underflow streams. Detailed procedures for the assessment of the DMC circuits were specifically tailored for each site.

After completing the initial site inspection, a detailed evaluation was undertaken to establish the baseline performance of the DMC circuits for each of the five selected plant sites. Partition curves were constructed from experiments conducted using density tracers of one or more sizes (i.e., 32 and/or 16 mm). As shown in Figure 2.1, density traces are simply plastic blocks (usually cubic) that incorporate high-density fillers to create particles with densities of 1.2 SG or higher with an accuracy of $\pm$0.005 SG. The blocks can be introduced into a separation process (such as DMCs) to mimic the behavior of particles of ore or coal.

During a typical test, a large number of tracers (≈500) of different SG values were selected based on the anticipated circuit operating conditions for each plant site. The tracers were added to the process feed stream, i.e., deslime screen oversize. Together with feed ore or coal, the tracers passed through the separator and reported to either the high- or low-density product streams as dictated by the particular characteristics of the DMC separation circuit. The tracers used in this project were brightly colored light red so that they could be visually located and manually retrieved from the product drain and rinse screens. The tracers recovered from overflow were counted separately from those that reported to underflow. A simple procedure was then followed to develop a partition curve for the DMCs at each site.

Figure 2.1. Density tracers sorted into groups of 20 each (1.52-1.64 SG) prior to being introduced into a DMC circuit.

Since the tracer technique eliminates the need for sample collection and laboratory analysis, the partitioning data obtained using tracers are generally considered to be more accurate than data derived using conventional sampling and float-sink procedures. More importantly, the partition curve can be obtained after only a short period of time (usually less than one hour). If conventional sampling procedures and float-sink analyses are used, the data are typically available only after a few weeks or more. During this time, the operating conditions within the DMC circuit may change and, as a result, the data obtained from the testing would be largely irrelevant.

In the current project, data from the tracer studies were used to assess the partitioning performance of the DMC circuits whose operating conditions were closely monitored and recorded. Key parameters monitored during the tests included plant feed rate, DMC inlet pressure and the SG values of the circulating medium streams (feed, overflow and underflow). Mass flow rates were estimated via collection of timed samples from the deslime screen oversize. The tracer data was then used as a guide to develop a detailed sampling program for each of the seven DMC circuits. As discussed below, the sampling program was performed under Task 4 – Follow-Up Assessment.

The test data from the baseline evaluation were used (i) to assess the potential for improving yield by manipulation or modification of equipment or operating parameters and (ii) to assess the performance of the DMC circuit in relation to other circuits in the plant (using any data available for the coarser circuits). Due regard was given to the principle that plant yield would be maximized when all circuits were operated as near as practical to conditions which generate equal incremental quality values (e.g., ash, inerts, Btu/lb, etc.). This important concept applies to parallel modules treating a specific size fraction as well as circuits treating other size fractions.

An evaluation of several primary ancillary operations was performed at each of the five plant sites to resolve any problems that may be identified during the baseline evaluation of the DMC circuits. This work was necessary since failures in other plant operations may be responsible for poor levels of performance within the DMC circuit. Examples include the evaluation of particle sizing equipment (screens and classifiers), magnetic separators, water clarification systems, plant pumping circuits, on-line sensors (mass rate, volumetric flows, pressure, density, etc.), control actuators, etc. Several of these problems were observed during the field testing portion of this project.

A *Baseline Report* was prepared and verbally presented to personnel at each plant site upon completion of the baseline evaluation. The narrative report presented the findings of the in-plant evaluation and recommended changes that were needed to fully optimize the performance of the DMC circuits at each plant. In many cases, the presentation also included recommended modifications to other plant circuits (e.g. feed medium density cutpoint for the dense medium vessel, improvements in instrumentation for monitoring medium density, etc.) that were necessary to achieve optimal plant performance. A face-to-face meeting was held with plant personnel at each site to review the baseline report and agree upon the extent and scheduling of required modifications.

Task 3 – Circuit Modification

A *Plant Modification Plan* was prepared by technical personnel at each plant site after completing the baseline evaluation. This internal plan, which was not circulated due to confidentiality agreements, outlined requirements for plant/circuit modifications and a work schedule with anticipated completion dates for required modifications. In some cases, these modifications included low-cost changes in plant operating practices (e.g., lower coal-to-medium ratios, higher percentage medium bleed, earlier screen replacement, etc.). All capital and labor costs associated with these plant modifications were entirely borne by the participating company.

Task 4 – Follow-Up Assessment

After completing the recommended upgrades, a second assessment of DMC circuit performance was conducted for each of the five plant sites. In this case, a full sampling campaign was conducted for all DMC circuits. All streams entering and leaving the DMC were sampled and subjected to laboratory float-sink analyses. The float-sink data were then used to mathematically construct partition curves for three different particle size classes (typically 16x8, 4x2 and 1x0.5 mm). The partition data for other size fractions present in the circuit feed were estimated by interpolation and extrapolation. Information generated during the past decade at JKMRC was particularly useful in this effort. The partition data obtained from the experimental sampling campaigns were then compared with the tracer data to compare the accuracy of the various methods in monitoring the performance of the DMC circuits at each of the five plant sites.

A *Final Plant Assessment Report* was prepared and submitted to the plant personnel at each plant site. Copies of these reports are provided in Appendix I of this report. For confidentiality reasons, the five plant sites have been identified as Plants A-E, respectively. As before, face-to-face meetings with plant personnel were held at each site to review the report and to discuss remaining open items.

Task 5 – Sample Analysis

Samples collected during the course of this work were placed in sealed containers and shipped to a commercial laboratory for analysis. Table 1.1 provides a summary of the typical analysis performed on each slurry sample. All samples were weighed, screened, filtered, dried and reweighed so that the dry mass and solids content could be determined. Unless otherwise specified, all size and density fractions were analyzed for ash and total sulphur contents. Each of the seven DMC evaluations conducted at the five plant sites involved float-sink analyses of three samples, i.e., DMC feed, overflow and underflow. Each of these samples were sized into several size fractions (i.e., plus 32, 32x16, 16x8, 8x4, 4x2, 2x1, 1x0.5 and minus 0.5 mm) using wet sieving. The 16x8, 4x2 and 1x0.5 mm size fractions were then subjected to float-sink analyses using dense liquids with SG values selected on the basis of the partition curves derived from the density tracer tests.

Table 1.1. Analysis requirements for the DMC slurry samples.

Analysis Procedure	Proposed Analysis Requirements
Particle Size Distribution	Screen each sample at 32, 16, 8, 4, 2, 1 and 0.5 mm and ash each size fraction.
Density Distribution	Float-sink the 16 x 8 mm, 4 x 2 mm and 1 x 0.5 mm size classes at preselected SG values and ash each density fraction.
Magnetics Distribution	Determine percent magnetics in minus 0.5 mm fraction and establish magnetics size distribution using laser diffraction method.

Task 6 – Data Analysis/Simulation

The flow rates and assay values measured around the DMC circuits were entered into a multi-component material balancing program and adjusted to obtain a consistent and reliable set of data. Values that required excessive adjustment were deemed unreliable and were removed from the data set. This procedure served to identify and correct shortcomings that are usually associated with experimental investigations of this type. Following such adjustments, the data were used to construct partition curves for the three pre-selected size fractions.

Task 7 – Expert System Development

This subtask involved the development of an expert system for DMC circuits that can be used by plant designers and operators to diagnose operating problems and optimize performance. Expert systems offer a convenient means of providing end users with expertise from a variety of knowledge sources including statistical expressions, process models and operator experience. In the case of DMC circuits, the expert system consisted of separate modules for diagnosis (trouble-shooting) and simulation.

The diagnostics module makes use of simple "if-then-else rules" to analyze process performance, evaluate possible alternatives, and suggest corrective actions. This module is supported by a simulation module that uses mathematical models (empirical or phenomenological) to predict the effects of various operating parameters on process performance. These modules allow operators to select optimum combinations of cyclone geometry, pressure head, medium grade, etc., for any desired duty. Particular attention was given to the development of a user-friendly interface that can be readily accepted by industry personnel without the need for extensive training or technical support.

Upon completing the refinement of the expert system, software documentation was distributed and training sessions were provided for key operating personnel. More than two dozen workshops were provided during the course of this project. The style and content of the sessions were tailored to suit the requirements and backgrounds of the various audiences. Most of the presentations were provided as half-day (≈3-4 hour) or one-day (≈6-7 hour) sessions.

Task 8 – Concept Assessment

All of the raw test data was compiled and provided to each of the project participants for analysis and review. Items addressed in the technical evaluation included (i) a summary of all major experimental data, engineering analyses and computations, (ii) a description of the capabilities of the process model and expert system developed from the technical data, and (iii) a head-to-head performance comparison of the tracer and experimental partitioning data for the various sites. All of these items are addressed in this technical report. An economic assessment was also performed internally to quantify the financial impacts associated with the proposed DMC circuit modifications.

Task 9 – Project Reporting

In order to monitor project progress, *Technical Progress Reports* were prepared and submitted to DOE on a quarterly basis. In addition, the submission of this document serves as a comprehensive *Final Report* for the overall project. This report presents all major experimental data, engineering analyses, computations, test results and major findings for the overall investigation. These items are presented in the following “Results and Discussion” section of this report.

RESULTS AND DISCUSSION

3.1 <u>Baseline Assessments</u>

3.1.1 Assessment of Plant A

The circuits at Plant A were tested using both 32 mm and 16 mm density tracers. Both the coarse coal and fine coal circuits were evaluated at this plant site. While some tracers were buried in the coal or refuse beds on the drain and rinse screens and were lost, those losses were not sufficient to seriously compromise the results. The density tracer results were discussed with plant management shortly after completing the test work.

a) Coarse Coal Circuit

The experimental density tracer data obtained during the testing of the coarse coal DMC circuit at Plant A is summarized in Figure 3.1. During this evaluation, the total plant feed rate for Plant A was about 2,282 t/h. According to the process control computer at the plant, coarse DMC medium density was being held at about 1.40 SG. Due to the low operating density cutpoint for this particular plant, tracers were provided at only two densities lower than 1.40 SG. Unlike some of the other plants, the nucleonic density gauge was located on a correct medium line (including no coarse coal), and adequate Marcy cup samples were recovered from a medium splitter. The Marcy gauge used was a balance-beam type. By comparison with the spring-and-dial type of gauge, the beam gives a steady reading, but was generally less precise. Allowing for a bias in the Marcy gauge, the true medium density appeared to be 1.41 SG units, which was just slightly higher than that reported by the K-Ray.

R D	Number of Tracers . . .													% to
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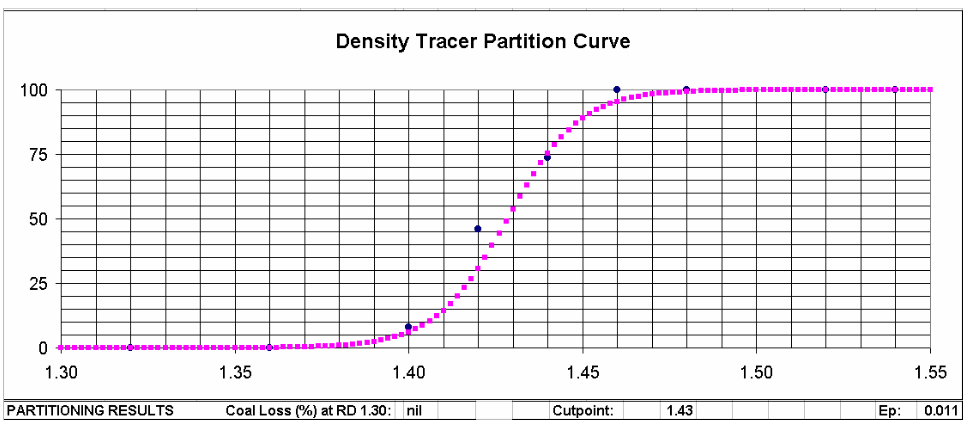
	a	1	2	3	4	5	b	1	2	3	4	c	d	
1.32	40	11	5	8	3	11	38	0	0	0	0	0	38	0
1.36	40	8	8	4	6	9	35	0	0	0	0	0	35	0
1.40	40	7	8	8	2	10	35	1	0	2	0	3	38	8
1.42	40	4	3	5	4	5	21	4	7	5	2	18	39	46
1.44	40	1	2	1	3	3	10	9	12	3	4	28	38	74
1.46	40	0	0	0	0	0	0	13	12	6	6	37	37	100
1.48	40	0	0	0	0	0	0	10	11	11	6	38	38	100
1.50	40	0	0	0	0	0	0	8	15	6	9	38	38	100
1.52	40	0	0	0	0	0	0	14	10	7	8	39	39	100
1.54	5	0	0	0	0	0	0	1	1	1	2	5	5	100
1.56	5	0	0	0	0	0	0	2	2	1	0	5	5	100
1.58	5	0	0	0	0	0	0	3	0	0	2	5	5	100
1.60	5	0	0	0	0	0	0	1	0	2	2	5	5	100
1.62	40	0	0	0	0	0	0	11	17	5	5	38	38	100
1.64	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.66	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.68	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.70	5	0	0	0	0	0	0	3	2	0	0	5	5	100



F igure 3.1. Density tracer data obtained for the coarse DMC circuit at Plant A.

The density cutpoint for the 32 mm density tracers was 1.43 SG, indicating an offset of only 0.02 SG above the medium density. The reason for this small offset may relate to DMC orifice sizes. There was no evidence of any retention of tracers of density close to the cutpoint SG. The Ep for the tracers was found to be 0.011, which is seen as a good result inasmuch as it represents the overall performance from a bank of five cyclones.

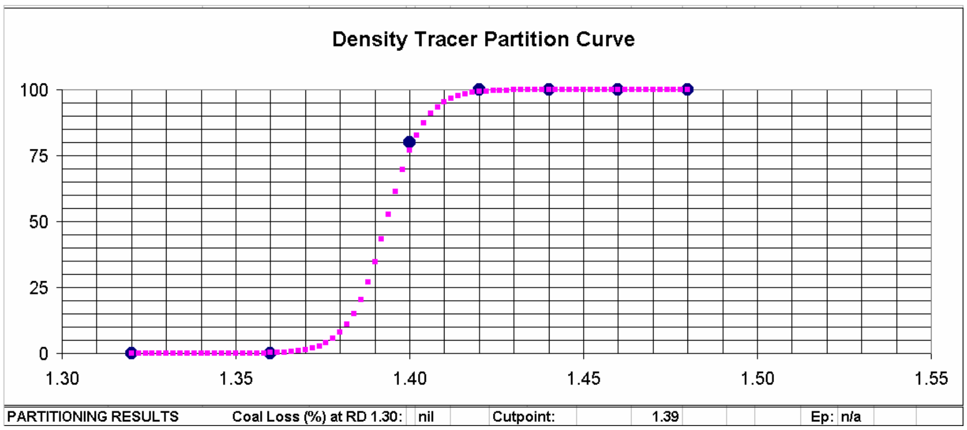
In general, the tracer data show that (i) no tracers of density less than 1.36 SG reported to refuse and (ii) no tracers of density greater than 1.47 SG reported to product. This implies that there was no gross misplacement of coarse coal or rejects and it is expected that the same will be found for smaller particles. While the data suggested that there was a bias of low-density particles away from the fourth DMC in the bank, this could not be verified since all by one of the five cyclones discharged into a common overflow box and a common underflow box.

b) Fine Coal Circuit

The experimental density tracer data obtained during the testing of the fine coal DMC circuit at Plant A is summarized in Figure 3.2. The evaluation of the fine DMC circuit was conducted at a plant feed rate of about 2,237 t/h. According to the process control computer, the fine DMC medium density was 1.38 SG. The tracer data indicate that (i) no tracers of density less than 1.36 SG reported to refuse and (ii) no tracers of density greater than 1.42 SG reported to product. This implies that there was no gross misplacement of coarse coal or rejects and it is expected that the same will be found for smaller particles.

For this circuit, Marcy cup samples of medium alone could be recovered from a head tank and were deemed more reliable. However, the nucleonic density gauge was located on the DMC feed line which included coal as well as medium. This arrangement makes it subject to a fluctuating error of up to about 0.05 SG, depending on the flow rate and density of the coal stream. Again, the Marcy gauge used in this circuit was the

R D	Number of Tracers . . .											% to U/flow
	in Feed	retrieved from…									Recovered	
		Overflow				Underflow						
		unit 1	unit 2	unit 3	Total	unit 1	unit 2	unit 3	unit 4	Total	b+c	
	a				b					c	d	
1.32	20	3	6	11	20	0	0	0	0	0	20	0
1.36	20	4	10	5	19	0	0	0	0	0	19	0
1.40	20	1	2	1	4	11	5	0	0	16	20	80
1.42	20	0	0	0	0	12	5	0	1	18	18	100
1.44	20	0	0	0	0	10	9	0	1	20	20	100
1.46	20	0	0	0	0	10	7	0	2	19	19	100
1.48	20	0	0	0	0	16	4	0	1	21	21	100



F igure 3.2. Density tracer data obtained for the fine DMC circuit at Plant A.

balance-beam type. By comparison with the spring-and-dial type, this type of device gives a steady reading, but is generally less precise. Allowing for a bias in the Marcy gauge, the true medium density appeared to be 1.39 SG, which was just slightly higher than that reported by the K-Ray. The 1.39 SG cutpoint for the 32 mm density tracers indicated an unusually small (negligible). The reason for this small offset may relate to DMC orifice sizes used in this circuit. However, there was no evidence of any retention of tracers with SG values close to the cutpoint. The Ep value for the 32 mm tracers could not be reliably determined due to the limited tracer densities available. The Ep did, however, appear to be very good. Again, a common overflow box and a common underflow box were used in this circuit, so performance differences between individual cyclones could not be assessed.

3.1.2 Assessment of Plant B

Both the primary and secondary DMC circuits at Plant B were tested using 32 mm density tracers. While some tracers were buried in the coal or refuse beds on the drain and rinse screens and were lost, those losses were not sufficient to seriously compromise the results. Many ancillary observations and measurements were also made as discussed in the following sections. On the day following the tests, partition curves were submitted to the plant superintendent and, later that week, the density tracer results were discussed with corporate personnel.

a) Primary Circuit

The density tracer data and partition curve obtained from these testing of the primary DMC circuit at Plant B tests are presented in Figure 3.3. According to the process control computer, the plant feed rate was 600 t/h. The primary DMC medium density was reported by this system to be 1.58 SG. Unfortunately, the nucleonic gauge for this circuit was located on the DMC feed line, which includes coal particles as well as medium. As a result, even when the control system maintains a constant slurry density, the density of the medium component tended to fluctuate by around 0.05 SG, depending on the flow rate and density of the feed coal particles. Marcy cup samples were recovered from the box which mixes medium streams returning from the drain-and-rinse screen underpans. One side of the box was more accessible and was usually sampled. The mixing seemed to be incomplete, so sampling at that point tended to underestimate the

R D	Number of Tracers . . .							% to
	in	retrieved from…					Recov	U/flow
	Feed	Overflow			Underflow		ered	
		unit	unit	Total	unit	Total	b+c	
	a	1	2	b	1	c	d	
1.50	40	22	16	38	0	0	38	0
1.66	40	16	16	32	0	0	32	0
1.68	40	22	9	31	0	0	31	0
1.70	40	14	14	28	0	0	28	0
1.72	40	19	13	32	2	2	34	6
1.74	40	13	9	22	12	12	34	35
1.76	40	6	1	7	24	24	31	77
1.78	40	0	1	1	27	27	28	96
1.80	40	0	0	0	31	31	31	100

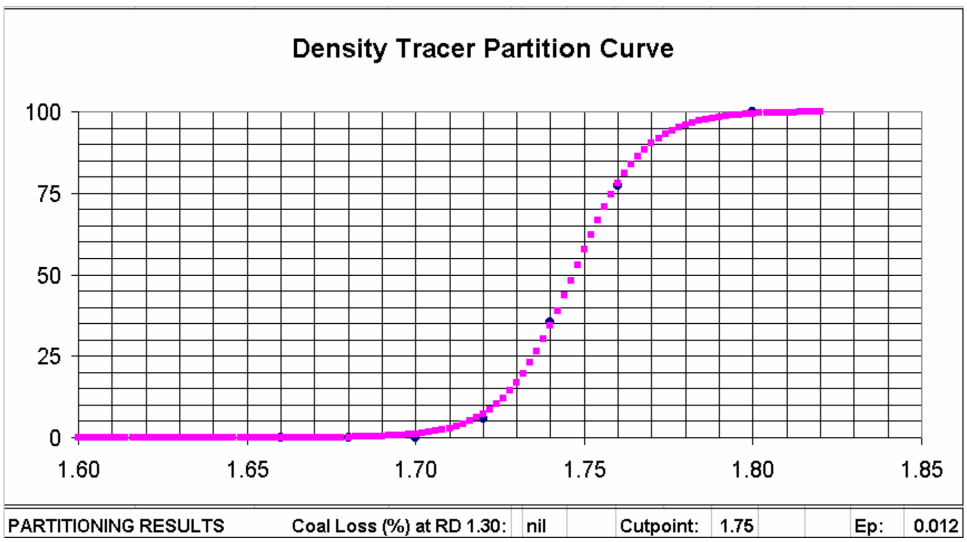


Figure 3.3. Density tracer data obtained for the primary DMC circuit at Plant B.

medium density. The outcome of all this is that the average density of circulating medium is higher than that reported by the nucleonic density gauge.

The tracer data showed that the cutpoint for the circuit was about 1.75 SG, indicating an offset of 0.15 SG. This offset was much greater than expected, especially at these relatively high densities. The principal cause of this was almost certainly the above-noted biases in the measurement of medium density. Fortunately, there was no evidence of any retention of tracers of density close to the cutpoint. In addition, the Ep for tracers was 0.012 SG units, which was considered to be a fairly good result. It is interesting to note that for such a high medium density, a high viscosity and poor Ep should have been expected. However, these issues did not appear to adversely impact circuit performance since the links between the primary and secondary circuits at this site were designed to combat this effect by maintaining coarser medium in the primary circuit.

If Plant B had incorporated a vessel, a result of the medium density measurement problem may have been that yield was lost by operating the vessel at an unnecessarily low cutpoint in order to achieve a target ash of combined product. Fortunately, that was not the case. The tracer data showed that (i) no tracers of density less than 1.72 SG reported to refuse and (ii) no tracers of density greater than 1.78 SG reported to product. This implies that there was no gross misplacement of coarse coal or refuse for this particular circuit. However, the float-sink results may show an unusually large Ep for smaller particles which are more strongly influenced by medium viscosity. To avoid this problem, it was recommended that a means be sought to reliably monitor feed medium density. Such means included (i) combining and mixing return medium streams and fitting the density gauge and a sample point to the combined medium before it is split between the draft tube and sump outer or (ii) an improved calibration procedure for the density gauge.

b) Secondary Circuit

The density tracer data and partition curve obtained from these testing of the secondary DMC circuit at Plant B tests are presented in Figure 3.4. Plant feed rate was 600 t/h and, according to the process control computer, primary DMC medium density

R D	Number of Tracers . . .						% to U/flow
	in Feed	retrieved from…				Recovered b+c	
		Overflow		Underflow			
		unit	Total	unit	Total		
	a	1	b	1	c	d	
1.32	40	36	36	2	2	38	5
1.36	40	29	29	10	10	39	26
1.40	40	1	1	39	39	40	98
1.42	40	0	0	40	40	40	100
1.52	40	0	0	39	39	39	100

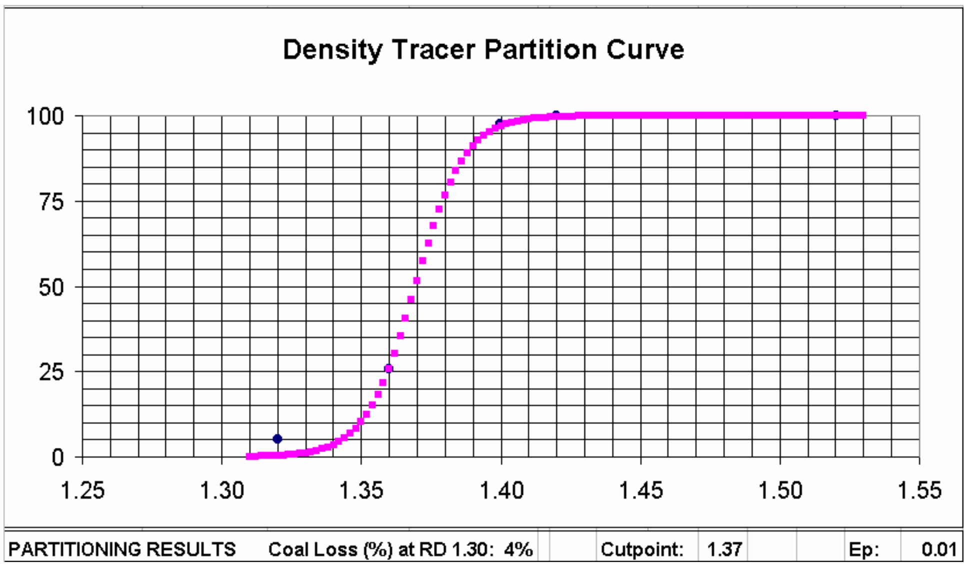


Figure 3.4. Density tracer data obtained for the secondary DMC circuit at Plant B.

was 1.33 SG. This DMC circuit was considered by plant management to be a critical separation with a very high proportion of near-gravity material.

For this circuit, the nucleonic gauge was appropriately located on the correct medium line after the pump and water addition point. In addition, it was possible to obtain reliable Marcy cup samples from a head tank. However, the Marcy measurements suggested that the nucleonic density gauge was reading high by about 0.05 SG. The high reading was not a major problem, however, so long as the performance was stable and the density cutpoint was moved up or down depending on ash content of the secondary product. However, for better record keeping and understanding of the plant behavior, more attention needed to be paid to the accuracy of medium density monitoring system.

This particular circuit was not on the original list of sites to be tested when the project proposal was made. Accordingly, tracers were available at only two densities lower than 1.40 SG. This constraint limited the definition of the partition curve, but the cutpoint was approximately 1.37 SG. This value indicates an offset of 0.09 SG units above the feed medium density, which is about as expected. Likewise, there was no evidence of any retention of tracers of density close to the SG cutpoint. The Ep value for the tracers appeared to be 0.01 SG units, which is reasonable but, as noted above, definition of the curve was less than optimal due to the limited number of tracers available with low densities. The tracer partition curve clearly shows that no tracers of density greater than 1.40 SG reported to product. While this implied that there was no gross misplacement of middlings, there appeared to be some evidence of a low-density "tail" showing minor misplacement of coal to middlings.

3.1.3 Assessment of Plant C

The DMC circuit at Plant C was tested using 32 mm density tracers. The results of this evaluation are summarized in Figure 3.5. During testing, the medium density according to the nucleonic density gauge was 1.60 SG. Therefore, it was anticipated that the cutpoint would be in the range of 1.65 to 1.70 SG. A preliminary test was conducted with only five tracers with densities from 1.60 to 1.80 SG, plus two lower densities in case the partition curve exhibited an undesirable low-density tail. The preliminary test showed that the cutpoint was surprisingly low and that there was some retention of tracers. The plant had been experiencing unplanned stoppages which had delayed the test

R D	Number of Tracers . . .												% to U/flow
	in Feed	retrieved from...										Recovered	
		Overflow							Underflow				
		unit	unit	unit	unit	unit	unit	Total	unit	unit	Total	b+c	
	a	A	B	C	D	E	F	b	A	B	c	d	
1.32	20	3	2	2	6	6	1	20	0	0	0	20	0
1.36	20	2	1	4	6	6	0	19	0	0	0	19	0
1.40	20	2	3	5	1	4	1	16	0	0	0	16	0
1.42	25	4	4	3	5	5	3	24	0	0	0	24	0
1.44	20	8	2	4	1	3	0	18	0	0	0	18	0
1.46	20	1	4	3	2	2	2	14	0	0	0	14	0
1.48	20	0	0	0	0	2	4	6	0	0	0	6	0
1.50	20	1	0	0	1	2	0	4	2	0	2	6	33
1.52	25	0	2	0	0	1	0	3	3	3	6	9	67
1.54	20	0	0	0	0	0	2	2	8	2	10	12	83
1.56	20	0	0	0	0	0	1	1	6	8	14	15	93
1.58	20	0	0	0	0	0	0	0	9	7	16	16	100
1.60	25	0	0	0	0	0	0	0	6	13	19	19	100
1.62	5	0	0	0	0	0	0	0	2	3	5	5	100
1.64	5	0	0	0	0	0	0	0	4	1	5	5	100
1.66	5	0	0	0	0	0	0	0	0	5	5	5	100
1.68	5	0	0	0	0	0	0	0	3	2	5	5	100
1.70	5	0	0	0	0	0	0	0	1	3	4	4	100
1.72	5	0	0	0	0	0	0	0	2	2	4	4	100
1.74	5	0	0	0	0	0	0	0	2	1	3	3	100
1.76	5	0	0	0	0	0	0	0	0	4	4	4	100
1.78	5	0	0	0	0	0	0	0	2	3	5	5	100
1.80	5	0	0	0	0	0	0	0	3	2	5	5	100

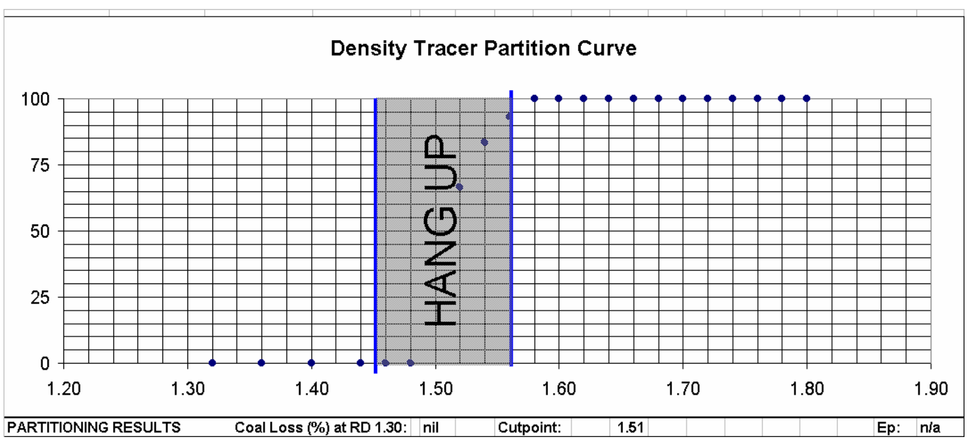


Figure 3.5. Density tracer data obtained for the DMC circuit at Plant C.

for several hours, and a plant water problem was developing which caused another shutdown. Therefore, tracers appropriate for the main test were quickly selected and added to the circuit. In effect, the preliminary and the main tests were combined, which explains the unusual range and numbers of tracers used in the various densities for this particular site. Because of the retention, it was considered unnecessary to use more than 25 tracers in any density class.

Plant feed rate was set at approximately 1,550 t/h and the DMC medium density cutpoint was 1.60 SG during the test program. The circuit layout did not incorporate a point where feed medium could be sampled without coal (or a nucleonic density gauge could be used to appropriately monitor the feed medium density without coal). Consequently, the density gauge could not be accurately calibrated for this site. Further, it was found that (i) the density gauge was located on a line which feeds only three of the six DMCs and (ii) the actual density of medium fluctuated by up to 0.05 SG units depending on the feed rate of coal particles and on the mean density of coal reporting to the DMC circuit.

Tracers of densities from 1.45 to 1.56 SG showed a strong tendency to be retained in the DMCs at this site, particularly in the second cyclone in the bank. The 32 mm density tracers are generally more prone to retention than the smaller coal particles, but the wide density range of retention was still a major concern in that this problem can lead to surging loss of coal to refuse. At the time of the test, the density gauge indicated a medium density of about 1.60 SG. The cutpoint for the density tracers which were not retained was around 1.51 SG. This difference was nearly 0.2 SG units below the expected value. Possible reasons of this discrepancy include (i) density gauge calibration error, (ii) inappropriate dimensions of DMC orifices, (iii) restriction of discharge from DMC orifices, (iv) particle retention leading to surging losses of coal to underflow, and (v) overload of the floats capacity of the DMCs. Because of the aforementioned problems, the three cyclones in one bank were inspected. The apexes were found to be in good condition and of identical diameter, which is a necessary condition for low Ep from parallel DMCs.

Due to the degree of retention of density tracers, the Ep value for this site could not be reliably determined. However, scrutiny of the tabulated data showed a considerable range in the highest density reporting to each product screen (1.46 SG for unit C to 1.56 for unit F). It also appeared that relatively few low-density tracers were presented to Unit F. These effects were consistent with a biased distribution of medium and coal through the 3-way distributors feeding the circuit. Combined with the low SG cutpoints, there was some likelihood that the DMCs were overloaded in terms of their ability to discharge floats product. Unfortunately, the plant situation did not allow the latter possibility to be directly assessed by running a test at a lower plant feed rate. However, the data clearly showed that (i) no tracers of density less than 1.50 SG reported to refuse and (ii) no tracers of density greater than 1.58 SG reported to the clean coal product. While this implies that there was no gross misplacement of coarse coal or rejects, the fact that the SG cutpoint is lower than the apparent feed medium density created some doubt as to whether the same level of performance would be true for smaller particles. As a result, some potential for yield improvement was expected for this particular circuit via increased medium flow and improved control of DMC cutpoint by comparison with vessel cutpoint. It was also recommended that a means be sought to reliably monitor feed medium density. Such means included (i) combining and mixing return medium streams and fitting the density gauge and a sample point to the combined medium before it is split between the draft tube and sump outer or (ii) fitting a very small sieve bend to the current sample points so that a coal-free sample of medium can be recovered, even if the density gauge is not relocated, and (iii) an improved calibration procedure for the density gauge. Other specific recommendations were also made to plant management related to improving feed distribution, DMC dimensions and capacity, and DMC discharge arrangements. All these modifications were accepted and implemented by the plant management.

3.1.4 Assessment of Plant D

The circuit at Plant D was tested using smaller 16 mm density tracers. The resulting data and partition curves are presented in Figure 3.6. While some tracers were buried in the coal or refuse beds on the drain and rinse screens and were lost, those losses were not sufficient to seriously compromise the results. The large (32 mm cube) tracers could have been used to minimise losses, but the smaller (16 mm cube) tracers were considered more relevant to the size range of coal treated at this particular plant.

According to the process control computer, plant feed rate was around 1,200 t/h and DMC medium density was 1.60 SG (relative density) during the evaluation period. Unlike some of the other plants evaluated in this study, the nucleonic density gauge was located on a line that contained only medium (no coarse coal). This design made it possible to accurately calibrate the density gauge against Marcy cup samples. At the time of testing, the Marcy measurements indicated a medium density of 1.57 SG, suggesting that the K-Ray instrument was reading a little high. The cutpoint for density tracers was found to be 1.60 SG, indicating an offset of only 0.03 SG units from the Marcy result. There was also little evidence of any retention of tracers of density close to the cutpoint.

The Ep value obtained for the density tracers was 0.017 SG, whereas a value of around 0.01 SG units should have been achievable for this operation. The partition curve clearly indicates that no tracers of density greater than 1.62 SG reported to the clean coal product and implies that there was no gross misplacement of rock. On the other hand, there is evidence of a low-density tail that indicates minor misplacement of low-density

R D	Number of Tracers . . .										% to U/flow
	in Feed	retrieved from…								Recovered	% ost
		Overflow					Underflow				
	a	unit 1	unit 2	unit 3	unit 4	Total b	unit 1	unit 2	Total c	b+c d	
1.50	40	14	5	3	6	28	0	2	2	30	7
1.52	40	10	4	6	9	29	0	0	0	29	0
1.54	40	10	1	6	9	26	0	1	1	27	4
1.56	40	9	2	5	9	25	0	2	2	27	7
1.58	40	7	5	3	12	27	2	7	9	36	25
1.60	40	8	2	2	6	18	3	10	13	31	42
1.62	40	1	2	0	4	7	11	18	29	36	81
1.64	40	0	0	0	0	0	8	29	37	37	100
1.66	40	0	0	0	0	0	14	19	33	33	100
1.68	40	0	0	0	0	0	8	30	38	38	100
1.70	40	0	0	0	0	0	7	26	33	33	100

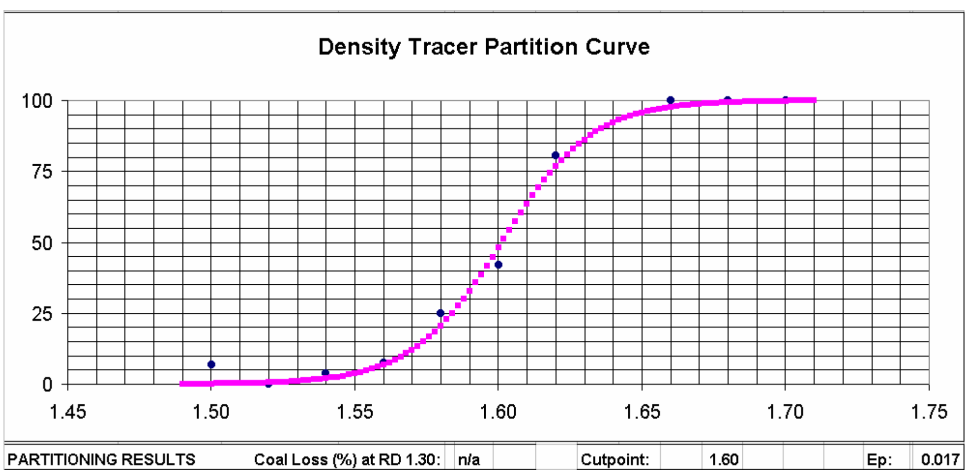


Fig. 3.6. Density tracer data obtained for the DMC circuit at Plant D.

coal particles to refuse. It is quite possible that each DMC was partitioning well, but that one unit was separating at a lower density than the other. This condition would produce the observed low SG offset and relatively poor Ep value. The low SG cutpoint may, in turn, be caused by clean coal overload or from surging. In any case, the clean coal yield has the potential to be increased for this circuit via (i) improvement in the sharpness of separation for the individual DMC units and (i) better control of the DMC cutpoint with respect to the vessel cutpoint.

3.1.5 Assessment of Plant E

The circuit at Plant E was tested using the standard 32 mm density tracers. The resulting data and partition curves are presented in Figure 3.7. Although this plant did not employ a process control computer, the control room operator attempted to maintain a plant feed rate of 800 t/h and medium density of 1.55 SG throughout the test period. While some tracers were buried in the coal or refuse beds on the drain and rinse screens and were lost, those losses were not sufficient to seriously compromise the test results.

The DMC circuit at Plant E did not incorporate a point where feed medium could be sampled, or a nucleonic density gauge can be applied to feed medium, in the absence of coal particles. Consequently, the density gauge could not be accurately calibrated for this particular site. Furthermore, the actual density of medium tended to fluctuate by up to 0.05 SG depending on the coal feed rate and mean density of feed reporting to the circuit. At the time of the density tracer test, the density gauge provided a reading of about 1.55 SG. The cutpoint for density tracers was 1.65 SG, suggesting an offset of about 0.10 SG units.

Tracers of densities 1.68 and 1.70 SG showed a strong tendency to be retained in the DMCs, particularly those which feed the second product screen. The retention was not in itself considered to be a significant problem in that large particles have a greater

R D	Number of Tracers . . .						% to U/flow
	in	retrieved from…				Recovered	
	Feed	Overflow			Under		
		unit	unit	Total	Flow	b+c	
	a	1	2	b	c	d	
1.50	20	9	7	16	0	16	0
1.52	20	6	9	15	0	15	0
1.54	20	8	9	17	0	17	0
1.56	20	6	8	14	0	14	0
1.58	20	7	11	18	0	18	0
1.60	20	6	9	15	0	15	0
1.62	20	6	9	15	5	20	25
1.64	20	1	10	11	8	19	42
1.66	20	0	7	7	11	18	61
1.68	20	0	1	1	5	6	83
1.70	20	0	0	0	10	10	100
1.72	5	0	0	0	4	4	100
1.74	5	0	0	0	4	4	100
1.76	5	0	0	0	5	5	100
1.78	5	0	0	0	5	5	100

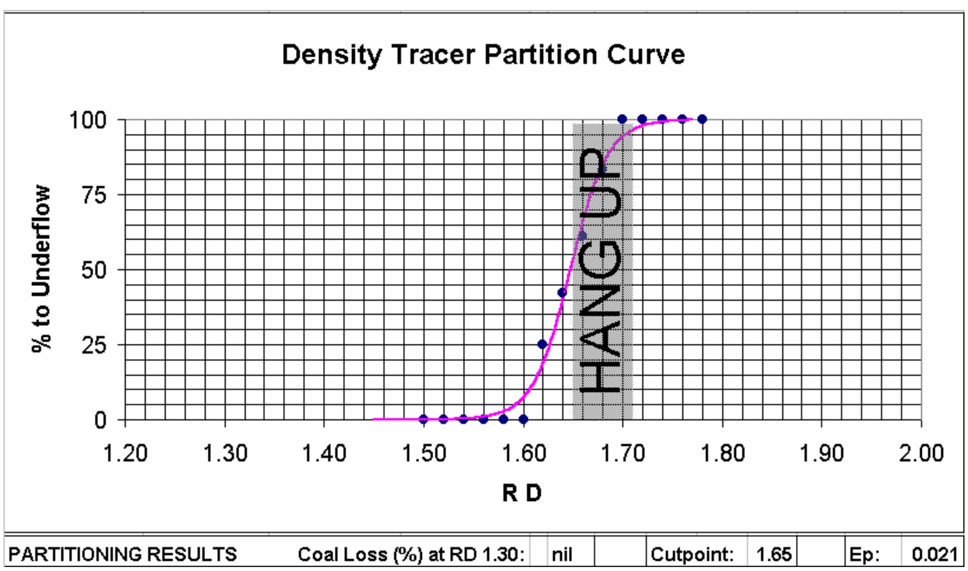


Figure 3.7. Density tracer data obtained for the DMC circuit at Plant E.

tendency to be retained and the 32 mm tracer cubes are larger than the feed coal for this circuit. However, the fact that retention was more prevalent in one cyclone suggests some kind of bias or performance difference for this particular unit. Likewise, the Ep value for the tracers was about 0.021 SG units, whereas half that value should have been achievable for this plant configuration. Further scrutiny of the tabulated data suggests strongly that the first DMC unit in the bank had a cutpoint about 0.04 SG units lower than that for the first unit, and was believed to be the primary cause of the relatively poor overall Ep value. The DMC apexes were found to be of similar size and were in reasonably good condition. Thus, the performance difference was probably due to a bias in feed distribution caused by the feed piping which was not symmetrical.

The preliminary tracer data for Plant E indicates that (i) no tracers of density less than 1.62 SG reported to refuse and (ii) no tracers of density greater than 1.68 SG reported to the clean coal product. This finding implies that there was no gross misplacement of either coarse coal or rejects. It was also expected that the misplacement would also be low for smaller particles. Therefore, major potential for yield improvement would only be possible through (i) equalization of SG cutpoints in the DMC circuit and (ii) better measurement and control of medium density for improved control of cutpoint with respect to the vessel cutpoint. Recommendations were also made to improve the reliably of the monitoring of the feed medium density. These recommendations included (i) combining and mixing return medium streams and fitting the density gauge and a sample point to the combined medium before it splits between the draft tube and sump outer or (ii) fitting a very small sieve bend to the current sample point so that a coal-free sample of medium can be recovered even if the density gauge is not relocated. An improved calibration procedure for the density gauge was also recommended for this plant site.

3.2 Follow-Up Assessments

This portion of the study was conducted as a detailed follow-up to the baseline assessments discussed in the previous section. The specific objectives of this portion of the investigation were:

(i) to determine whether useful performance data and performance estimates for all sizes can be quickly generated using density tracers supported by other on-the-spot observations including Marcy cup measurements of the densities of feed, overflow and underflow medium,

(ii) to compare such estimates with the results of conventional float/sink analyses which are much more time-consuming and expensive, and

(iii) to utilize the tracer results to identify any inefficiencies and develop recommendations for corrective actions.

Detailed site reports summarizing the data from the follow-up assessments are provided in Appendices A-E for each of the five processing facilities (all seven DMC circuits) evaluated in this study. A summary of the general observations deemed from these reports are discussed in the following sections.

3.2.1 Density Tracer Results

The effectiveness of density tracers in trouble-shooting dense medium cyclone performance was demonstrated at each of the five preparation plants. It should be noted that two different DMC circuits were evaluated at plants A and B, while only one circuit was evaluated at the other sites. The evaluations were carried out using 32 and/or 16 mm density tracers. The normalized partition data for each circuit are given in Figure 3.8. In this case, the densities reported on the x-axis have been normalized by dividing the SG by the SG cutpoint (SG_{50}) so that the data from the various circuits can be compared.

Despite the wide range of coal types treated by these circuits, the partition data show that the separations provided by the DMC cyclones were relatively sharp (Ep<0.02) and most showed no gross misplacement of either clean coal or refuse. The only major exceptions to this conclusion were for Plant B (circuit B2) and Plant D. The partition

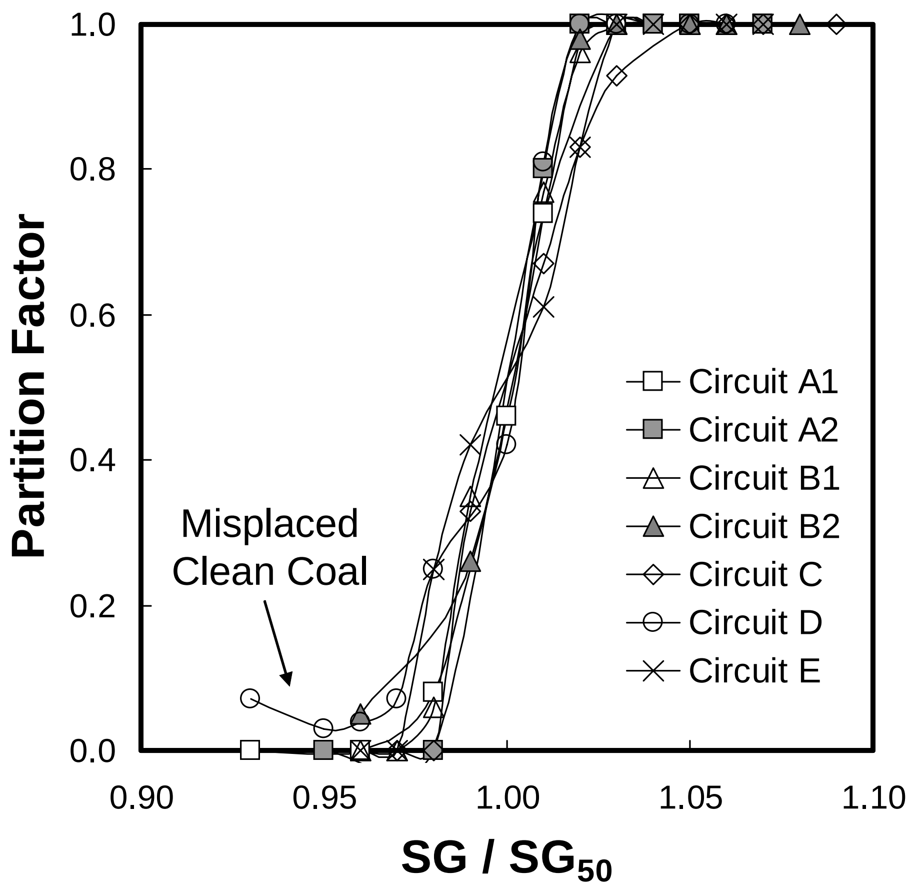
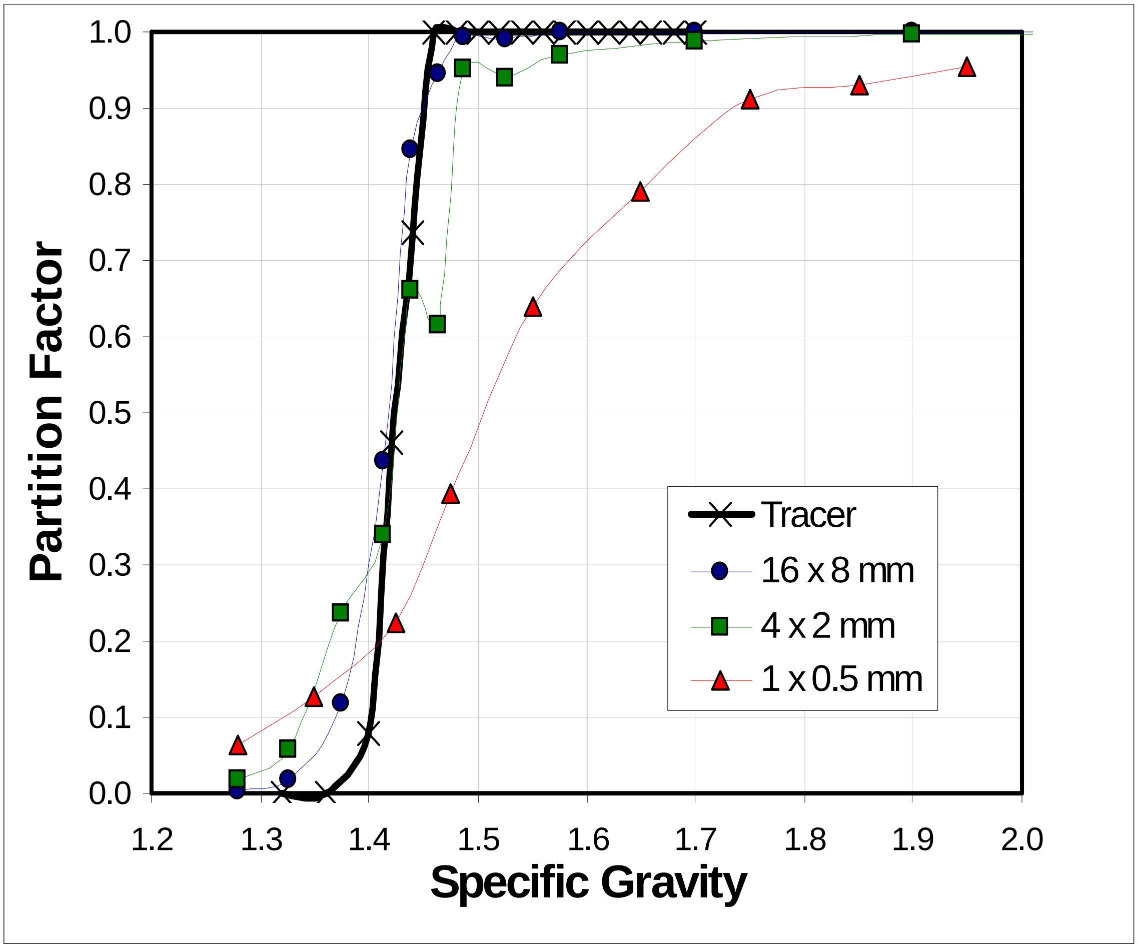


Figure 3.8. Summary of tracer partition curves obtained for the seven DMC circuits and five plants evaluated in this study.

curves for both of these circuits displayed a low-density tail that is indicative of clean coal losses. In particular, the follow-up evaluations showed that the DMC circuits at these two plants were overloaded and the recommended medium-to-coal ratios were not being maintained. Increasing the volumetric flow rate of medium to the DMC circuits by increasing the speed of the DMC feed pumps eliminated these problems at both plant sites. As discussed previously, all dense medium circuits should be operated at the same SG cutpoints in order to optimize total plant yield at a given clean coal quality. To avoid differences in cutpoints, all cyclone components (i.e., apexes and vortex finders) on the same bank of DMCs must be of the same size and type. Also, the feed distribution system must be configured so that each cyclone in a bank receives the same flow rate and quality of feed coal and medium. Failure to do so can result in significant losses of clean coal yield for the overall plant.

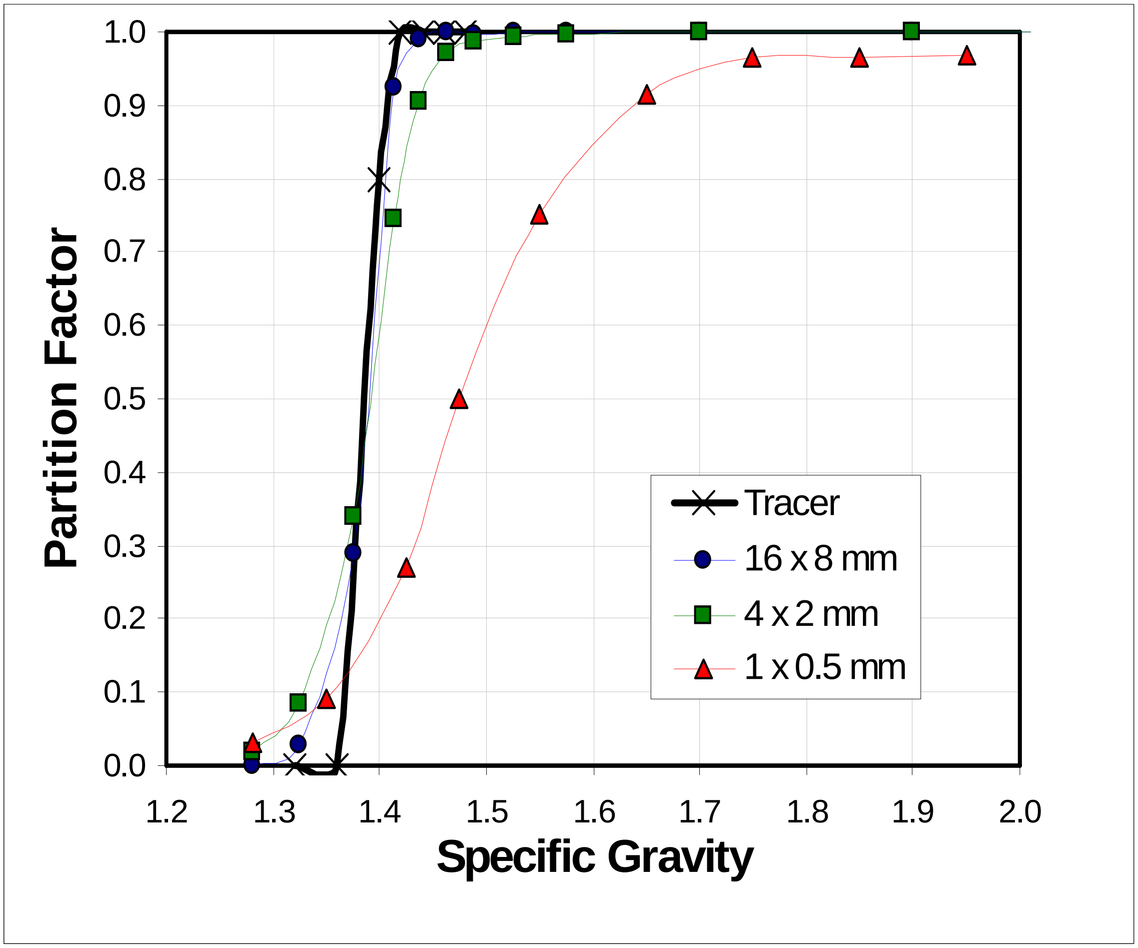
3.2.2 Coal Partitioning Performance

Coal samples were collected at each of the plant sites and used to construct experimental partition curves to compare with those obtained using the synthetic density tracers. The comparative data are shown in Figures 3.9-3.15 for Plant A through Plant E, respectively. As should be expected, the partition curve for the tracers was a little sharper than that obtained for the coarsest size fraction of coal, partly due to the greater resolution of the density tracer technique. The coal data also showed a general progression of increasing Ep with decreasing particle size; however, the partition curves for both tracers and coal gave Ep values which were not excessively large. This finding indicates that the multiple DMCs in each test circuit are in a reasonably similar state of repair (especially in respect of apex diameter).



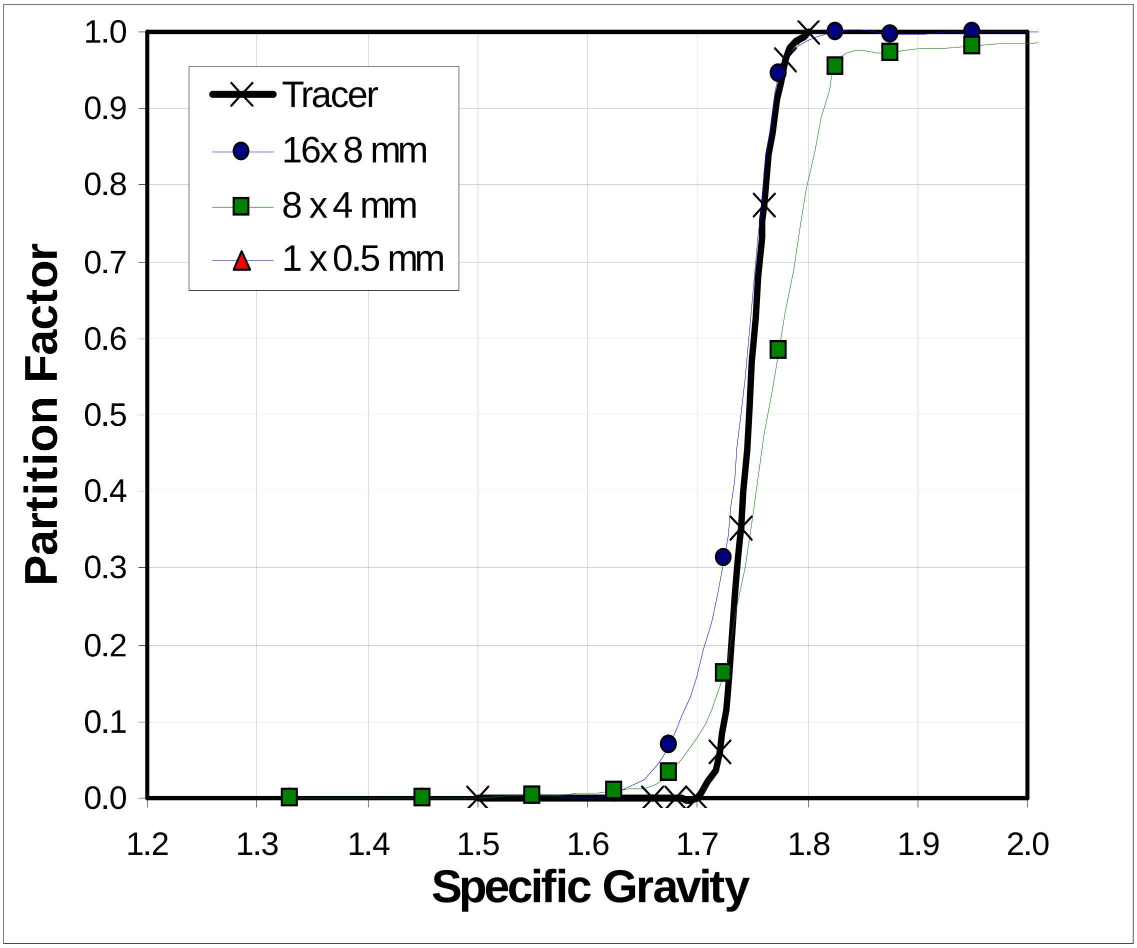
Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.430	0.011
Coal (16 x 8 mm)	1.416	0.019
Coal (4 x 2 mm)	1.415	0.035
Coal (1 x 0.5 mm)	1.487	0.103

Figure 3.9. Experimental partition data for Plant A (Coarse DMCs).



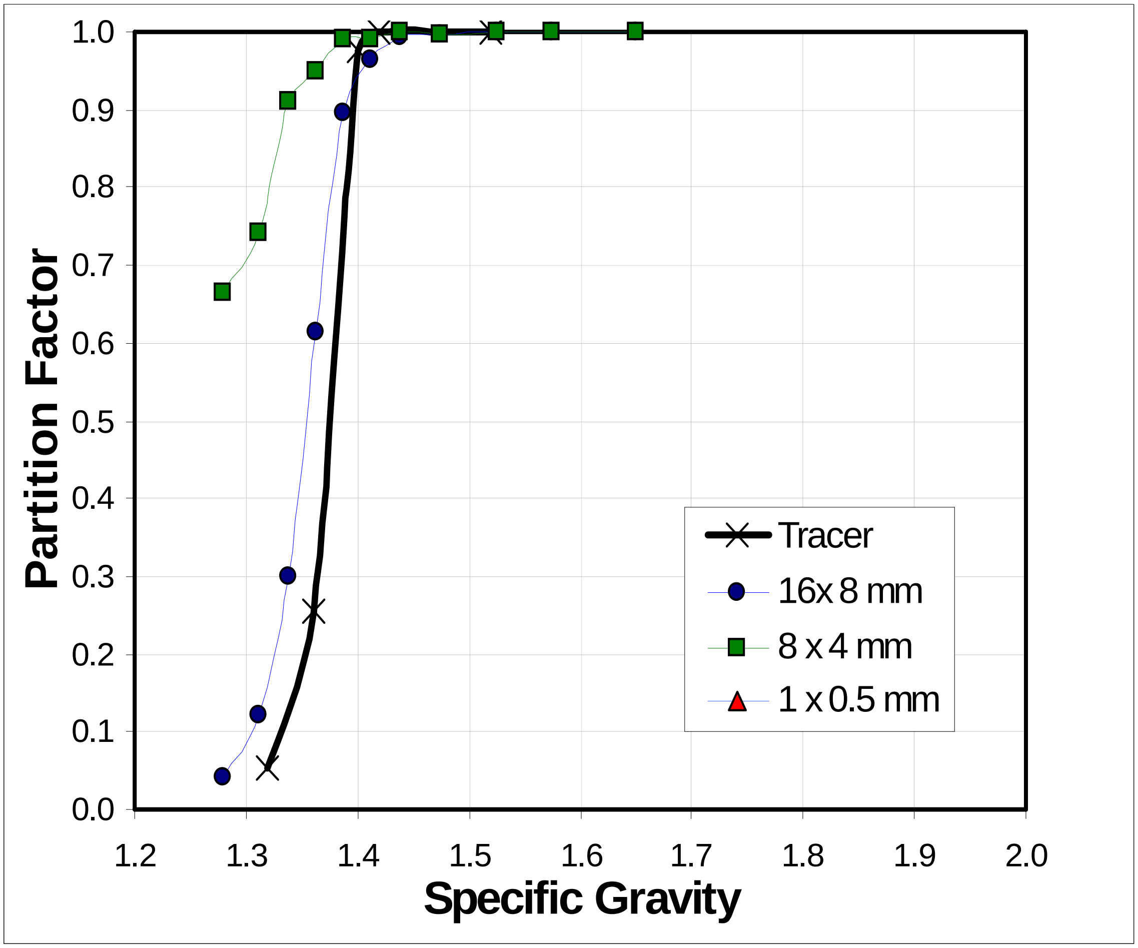
Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.390	0.005
Coal (16 x 8 mm)	1.385	0.012
Coal (4 x 2 mm)	1.385	0.026
Coal (1 x 0.5 mm)	1.491	0.071

Figure 3.10. Experimental partition data for Plant A (Fine DMCs).



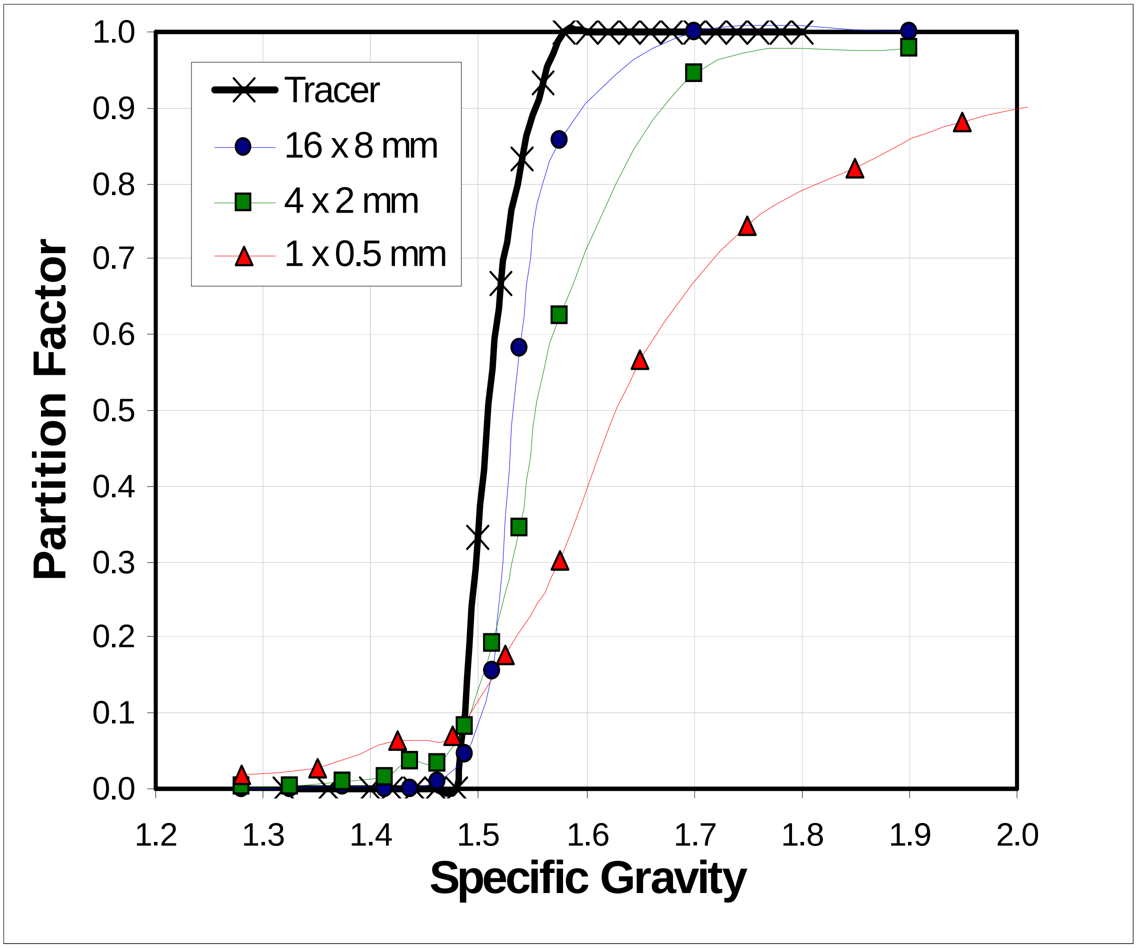
Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.740	0.012
Coal (16 x 8 mm)	1.720	0.020
Coal (4 x 2 mm)	1.765	0.026
Coal (1 x 0.5 mm)	---	---

Figure 3.11. Experimental partition data for Plant B (Primary DMCs).



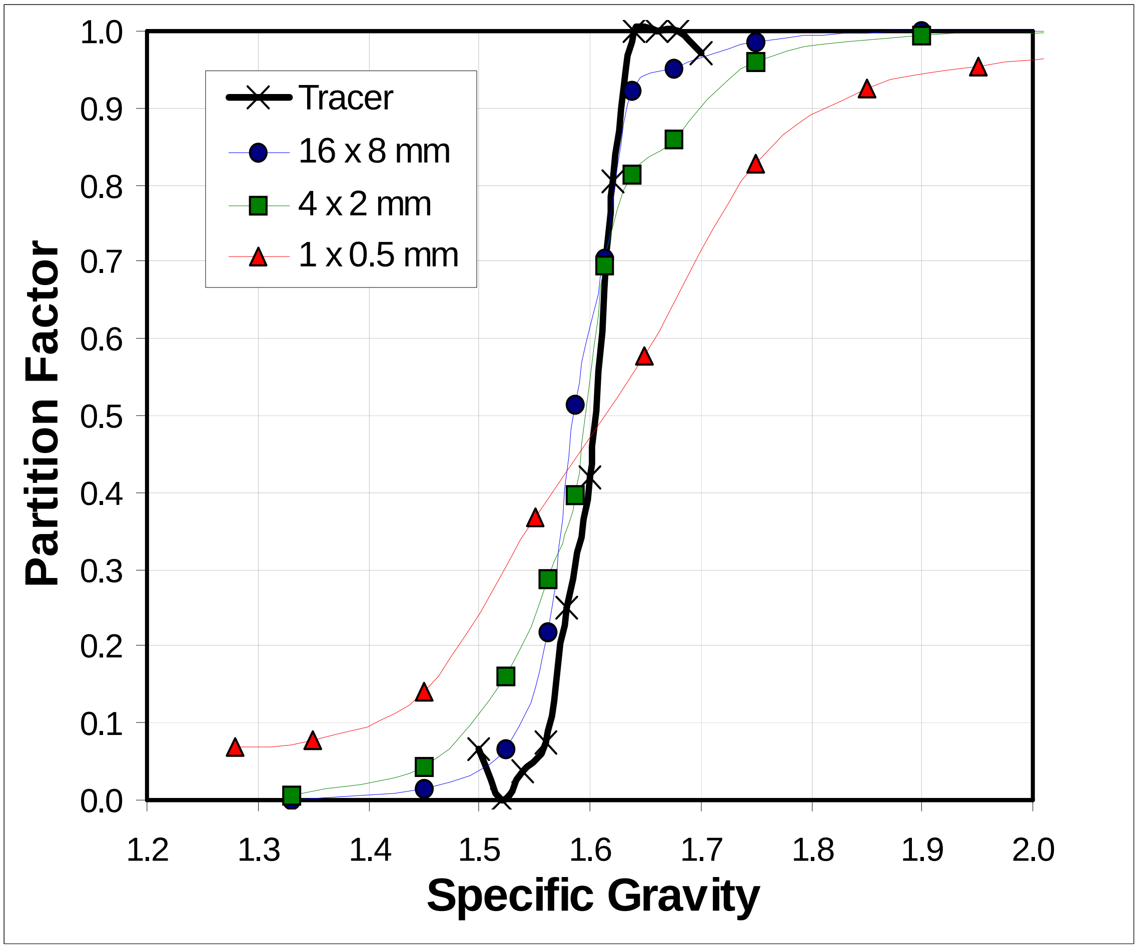
Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.370	0.010
Coal (16 x 8 mm)	1.342	0.021
Coal (4 x 2 mm)	1.248	0.038
Coal (1 x 0.5 mm)	---	---

Figure 3.12. Experimental partition data for Plant B (Secondary DMCs).



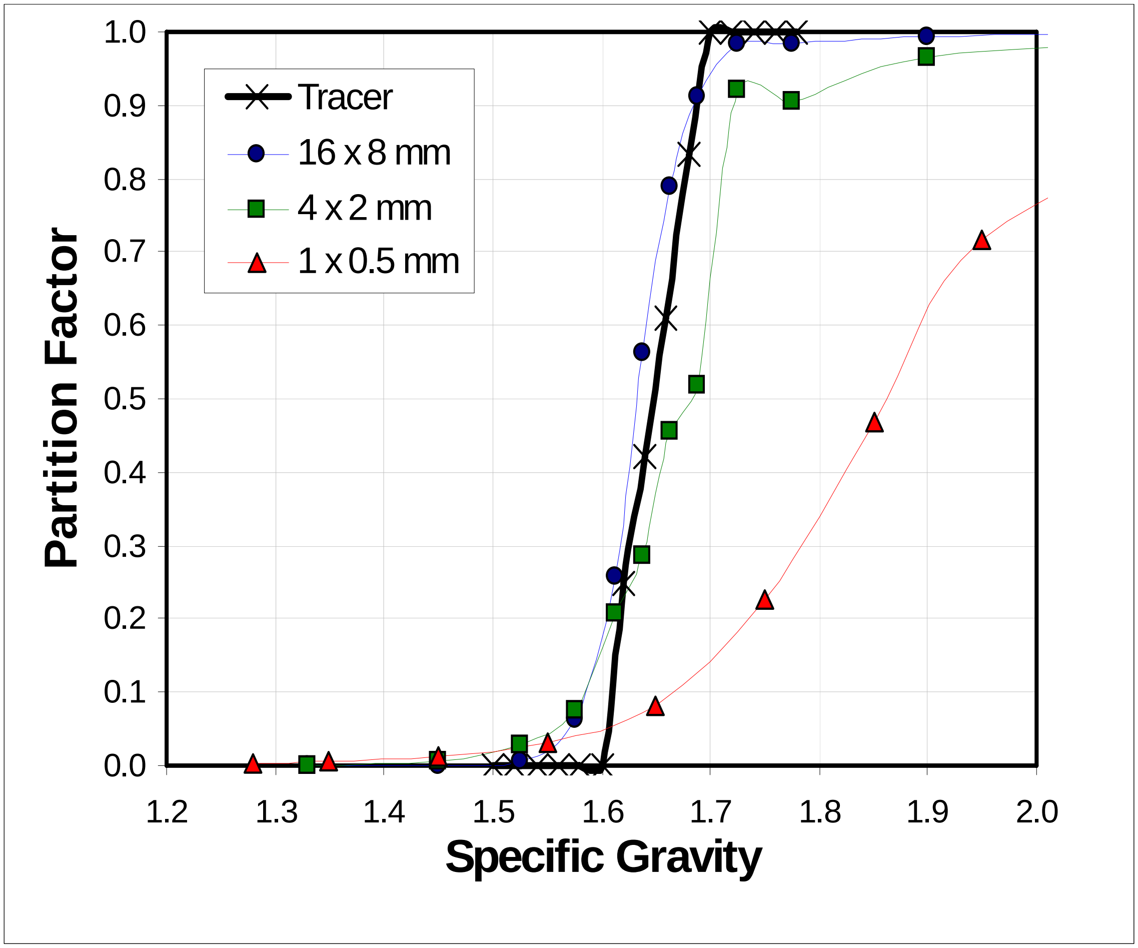
Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.150	0.015
Coal (16 x 8 mm)	1.540	0.020
Coal (4 x 2 mm)	1.563	0.038
Coal (1 x 0.5 mm)	1.681	0.110

Figure 3.13. Experimental partition data for Plant C.



Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.600	0.016
Coal (16 x 8 mm)	1.588	0.024
Coal (4 x 2 mm)	1.591	0.045
Coal (1 x 0.5 mm)	1.606	0.110

Figure 3.14. Experimental partition data for Plant D.



Description	SG Cutpoint	Separation Ep
Tracers (32 mm)	1.650	0.021
Coal (16 x 8 mm)	1.634	0.024
Coal (4 x 2 mm)	1.660	0.036
Coal (1 x 0.5 mm)	1.896	0.122

Figure 3.15. Experimental partition data for Plant E.

General comments related to the performance of the DMC circuits at each of the five plant sites are discussed in the following paragraphs.

Plant A: The data obtained for the coarse coal DMC circuit at Plant A are generally indicate of good DMC performance (aside from an experimental anomaly in the curve for the 4 x 2 mm coal particles). For the coarse DMC circuit, worn apexes and poor matching of the SG cutpoint with those of vessels and fine DMCs were the largest contributors to coal losses. These problems were eliminated by improved measurement and control of medium densities and offsets. For the fine DMC circuit, the low pivot obtained in the test program suggests a very small ratio of apex diameter to vortex finder diameter that needs to be corrected. Also, as with the coarse circuit, replacement of worn apexes and better matching of cutpoint SG with those of vessels and coarse DMCs would minimize coal losses at this site. Fortunately, the partition data indicate that coal losses were relatively small at this particular site.

Plant B: For both the primary and secondary DMCs at Plant B, the cutpoints for tracers were found to be somewhat higher than those obtained for the coal particles. This type of finding is often the result of the absorption by the coal particles of water and/or of float/sink liquids. For this plant, the capacity for efficient operation is limited by insufficient screening capacity in the secondary circuit and by low flow to the primary DMCs. These bottlenecks could be eliminated by installing larger screens and by increasing primary DMC pump speed. Some problems with density measurement were also noted and corrected at this site. Total coal losses for the primary circuit were estimated to be <0.2% of the total feed. There was also a minor loss of secondary product to the middlings product.

Plant C: As for the fine coal circuit at Plant A, the partition results suggest an unusually small ratio of apex to vortex finder diameter. In addition, the tracer data showed there was retention of density tracers in the range of 1.48 to 1.52 SG. The retention of tracers implies that some danger exists for loss of coal to rejects due to surging. Coal losses, attributed to poor matching of SG cutpoint with that of the vessel, were minimized by improved measurement and control of medium densities and offsets. High magnetite losses due to poor rinsing and poor control of magnetic separators was also observed at this particular site. The total loss of coal due to these problems was estimated to be <0.2% of total yield.

Plant D: The relatively high pivot point in the partition plot for this particular plant suggests that the apex to vortex finder ratio may be a somewhat too large for optimal performance. Badly worn apexes, low inlet pressure and a biased split from the DMC feed distributor was observed and contributed to coal losses. These problems were quickly addressed by the plant management and the corresponding coal losses eliminated, even at increased throughput. However, prior to implementing these corrections, the problems were responsible for a reduction in plant yield of at least 2%.

Plant E: The low pivot point in the partition data for this plant site is again indicative of a small ratio of apex to vortex diameter which can result in lost coal. In addition, the retention of tracers in the 1.68 to 1.70 SG range indicates that a danger exists for coal losses due to surging. Medium density could not be accurately monitored at this site; however, at the time of testing, this shortcoming did not appear to be causing any significant loss of yield. The partition data indicate that coal losses were <0.2% for this particular site.

3.2.3 *Tracer Prediction Capabilities*

Figure 3.16 compares the predicted (solid lines) and experimental (points) partition data obtained for each of the seven DMC circuits examined in this investigation. The predicted values were calculated using only (i) the density tracer partition data and (ii) the SG values of the medium streams (feed, overflow and underflow). The Ecart probable (Ep) and SG cutpoint (ρ_{50}) for any size fraction was estimated using:

$$Ep = 0.037 / D_p \ x \ C1 \ x \ C2 + C3 \qquad [3.1]$$

$$\rho_{50} = \frac{Ep}{1.0986} \ln\left(\frac{1}{S_u} - 1\right) + \rho_{50}^{*} \qquad [3.2]$$

where D_p is the mean particle size, C1 is a correction factor for laboratory inefficiencies (usually 1.5), C2 is a correction factor for O&M considerations (1.0=excellent, 1.2=good, 1.5=poor), and C3 is a correction for cutpoint differences between the units (which ranged from 0-0.02 for this study), S_u is the faction of medium reporting to underflow, and ρ_{50}* is the pivot point density. Details related to the empirical modelling equations are discussed in the simulation and modelling section of this report. For reference, the detailed partition calculations are provided in Appendix II for each plant site.

In general, the predicted partition curves are in relatively good agreement with the actual experimental values for each of the seven circuits evaluated in this study. In particular, the predictions made for Plants A, B, C and D were found to be very close to the partition values obtained from the float-sink tests conducted on the actual coal samples. On the other hand, some difficulties were noted in the predictions made for Plant B. In this case, difficulties associated with the laboratory float-sink tests and the aforementioned plant operating problems made the predictions unreliable.

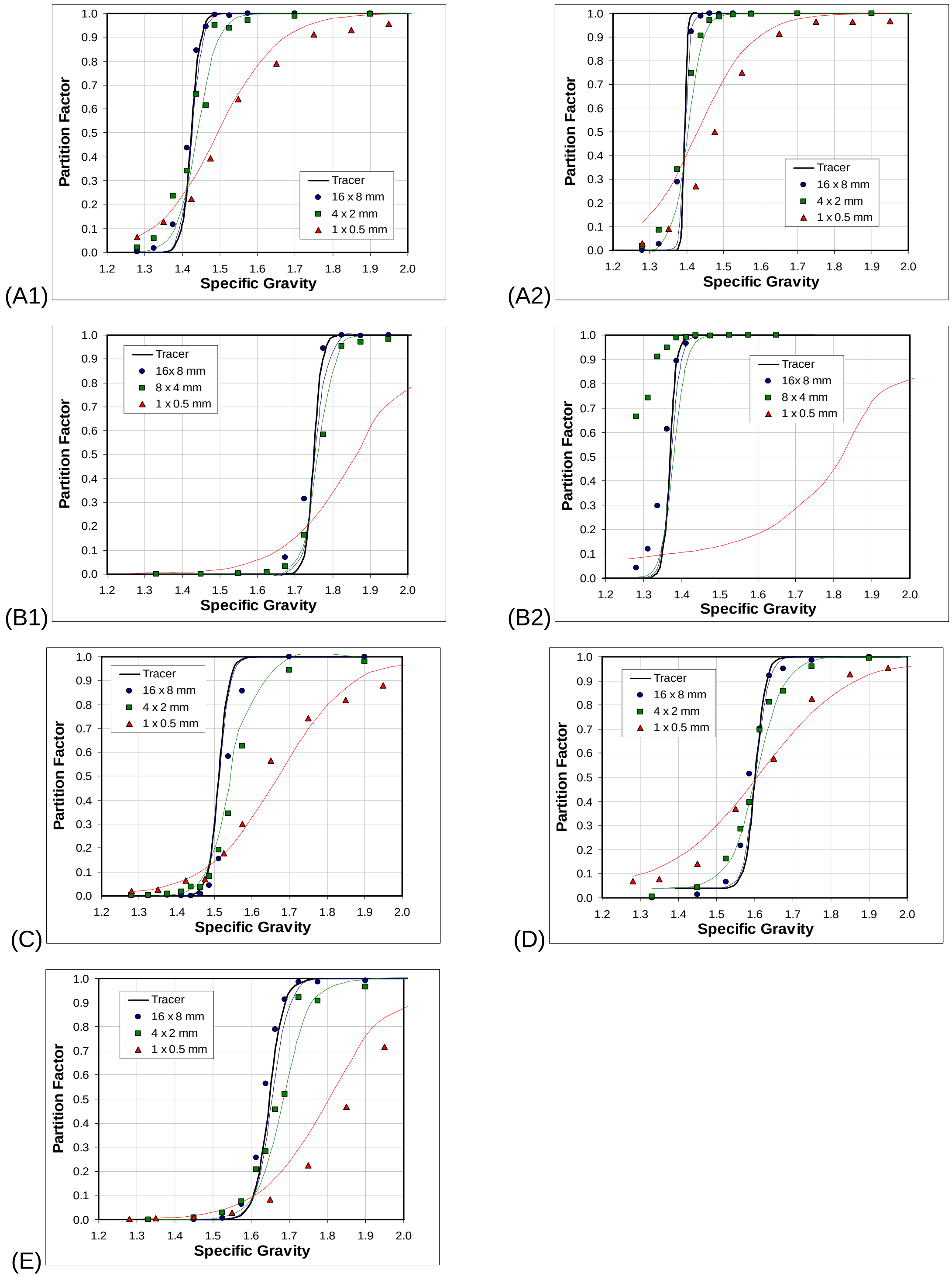


Figure 3.16. Comparison of predicted (lines) and experimental (points) partition data for different size fractions treated by DMC circuits at plant sites A-E.

3.2.4 Cutpoint Monitoring and Control

The global optimization of a coal preparation plant requires that the specific gravity cutpoints of the dense medium vessel and dense medium cyclone circuits be essentially identical. Since dense medium cyclones operate at actual cutpoints that are slightly higher than the SG of the circulating medium, the specific gravity of the circulating medium for the dense medium vessel will normally need to be set higher than that of the circulating medium in the dense medium cyclone circuit. The difference or offset, which is normally less than 0.10 SG units, must be determined for each plant. If cutpoint must be changed, it should change by the same amount in both the dense medium vessel and dense medium cyclone circuits to maximize plant wide yield.

The ability of the operator to maintain the proper SG cutpoint is complicated by the fact that nuclear density gauges (K-Ray) are not always calibrated properly. For example, Table 3.1 compares K-Ray readings from the seven different DMC circuits to manual SG readings taken using a Marcy scale. As shown, the K-Ray readings differed from the manual readings by about 0.02 to 0.14 absolute SG points. To avoid this problem, experimental density readings need to be taken at each plant site using a Marcy

Table 3.1. Comparison of SG readings at each of the plant test sites.

Plant/ Circuit	K-Ray SG	Marcy SG	SG Difference
A/1	1.40	1.45	-0.05
A/2	1.38	1.43	-0.05
B/1	1.58	1.60	-0.02
B/2	1.33	1.28	+0.05
C	1.55	1.48	+0.07
D	1.59	1.45	+0.14
E	1.60	1.57	+0.03

scale (or similar device) and compared to the K-Ray readings throughout the operating shift.

3.3 Modeling and Simulation

In order to help operators optimize DMC circuits, a collection of software tools were developed as part of this project. These tools include (i) a mass balancing routine for analyzing test data, (ii) a process model for predict-ing the effects of key operating and design variables, and (iii) an expert advisor that provides plant operators with an interactive interface for trouble-shooting DMC problems. Brief descriptions of each of these tools are provided in the following sections.

3.3.1 Mass Balancing Routines

Mass balances are commonly to evaluate the reliability of experimental data and to make statistically sound estimates of true values (Wills, 1997). For DMC circuits, the mathematics associated with mass balances can be difficult due to conflicting data created by the large number of size fractions and SG classes. To address this problem, a spreadsheet-based mass balance program was developed using optimization tools embedded in modern spreadsheet programs (e.g., Microsoft Excel). To utilize this program, users simply enter the assay values (i.e., ash, sulfur, heat content, etc.) for each stream around the DMC. The built-in minimization routines then generate the best estimates of the assay values and flag values that may be unreliable. The routines incorporated within the spreadsheet-based platform can be readily modified to handle specific problems without the need for any formal programming experience.

To illustrate the importance of the mass balancing, a partition curve was constructed for a bank of four parallel DMCs at one of the test sites evaluated in this project. As shown in Figure 3.17, the partition curve constructed based on the unbalanced data shows considerable scatter due to errors in sample collection and analysis. The excessive scatter makes it essentially impossible to quantify the performance of the circuit in an unbiased manner. In contrast, the partition curve constructed using the balanced data can be easily interpreted in a statistically meaningful way.

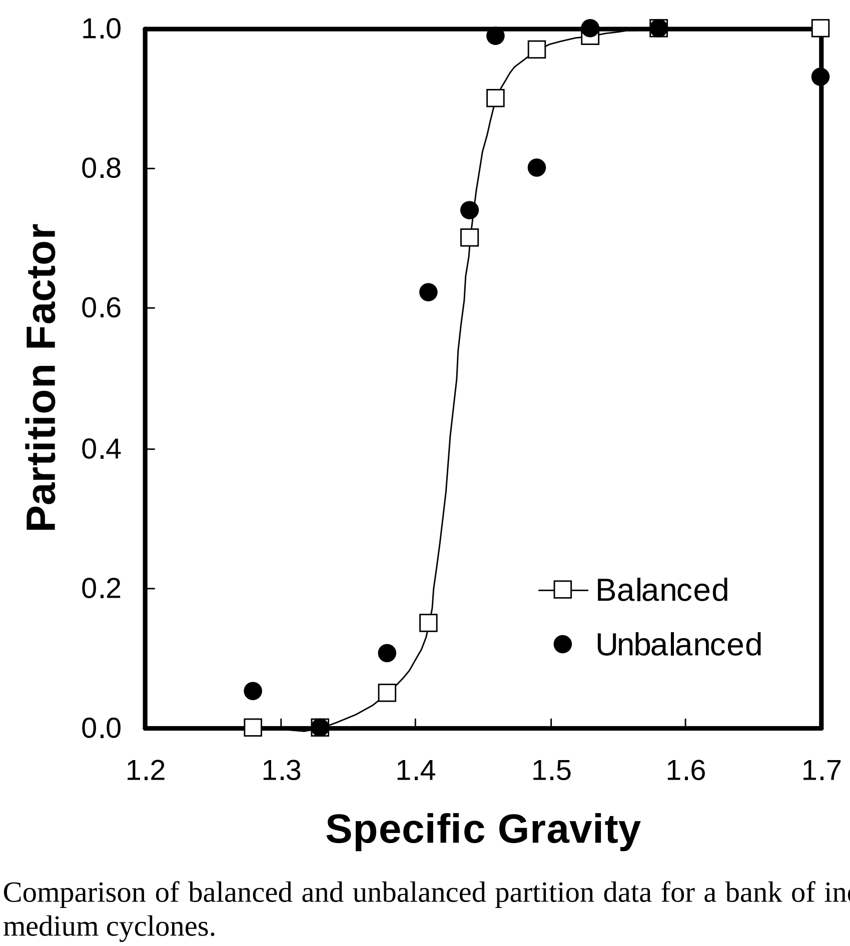


Fig. 3.17. Comparison of balanced and unbalanced partition data for a bank of industrial dense medium cyclones.

3.3.2 DMC Process Model

Tremendous benefits may be realized through the proper initial design of DMC circuits. To assist in this effort, a simulation program has been developed based largely on model expressions by Wood et al. (1987, 1990, 1997) and others (Davis, 1987; Scott, 1988; Restarick and Krnic, 1990; Clarkson and Wood, 1991). Like the mass balance routines, the simulator uses a spreadsheet-based platform that is easy to use and modify. Input values to the simulation package include feed washability characteristics, design variables (e.g., cyclone diameter), and operating variables (e.g., inlet pressure, medium density, etc.). The simulation package can be used (i) to predict the partitioning performance of DMCs and (ii) to identify potential DMC problems such as unwanted retention, incorrect medium splits, inadequate medium flow rates, excessive dry feed mass rates, etc. Figure 3.18 provides a flowchart for the sequence of calculations used in the DMC simulation.

a) Medium Calculations

The first series of calculations involve the determination of volumetric flow rates. The total volumetric feed capacity (Q_f) of the cyclone can be estimated from:

$$Q_f = K D_c^{1.48} R^{0.15} H^{0.45} \quad [3.3]$$

in which K is an empirical coefficient, D_c the cyclone diameter, R the ratio of the apex-to-vortex diameter, and H is the total inlet head. The simulation routines assume that Q_f is independent of coal loading. The volumetric flow rate of medium to the underflow in the absence of feed (Q_{um}*) can now be estimated using:

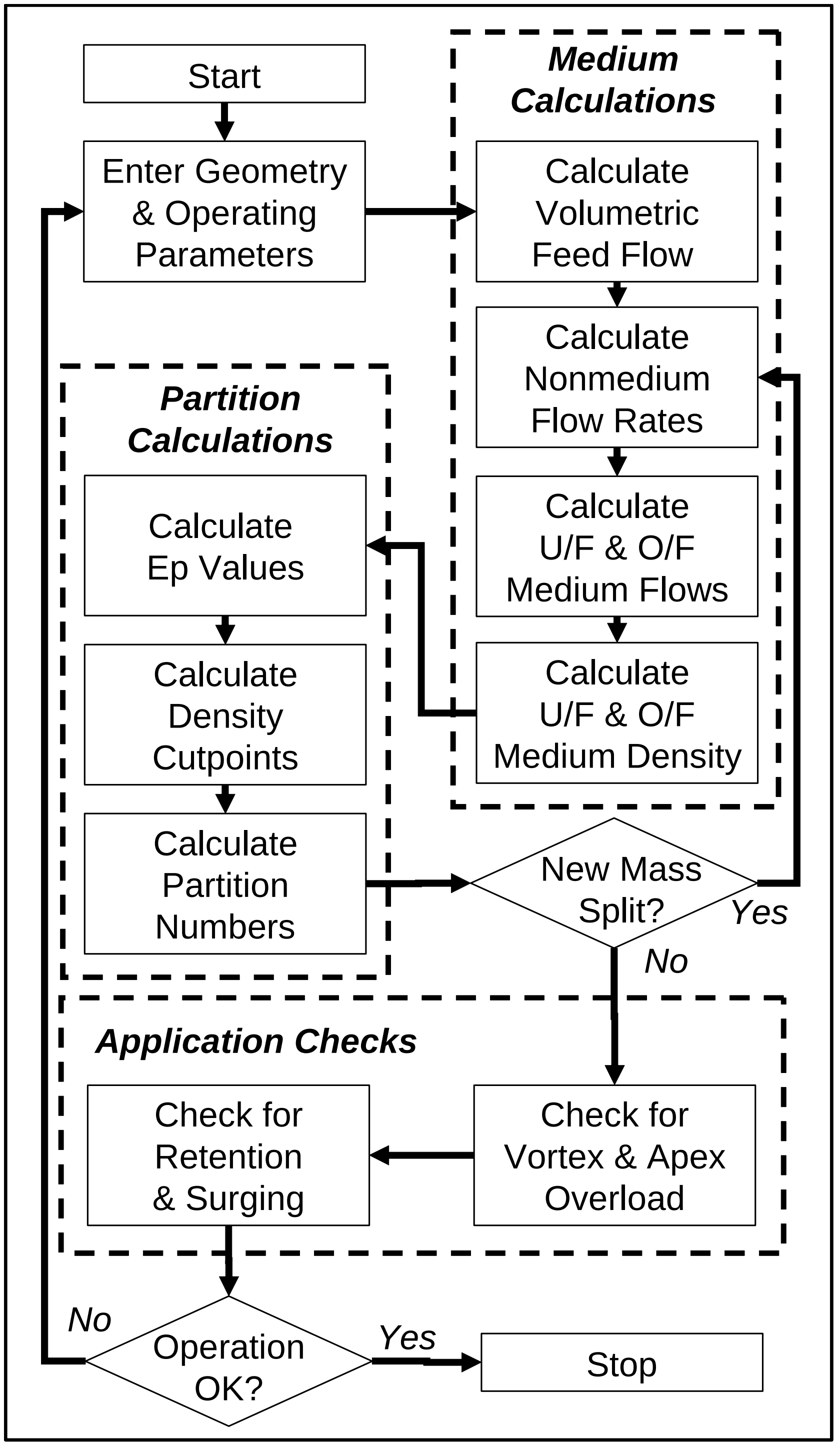


Figure 3.18. Flowchart for the DMC simulation routines.

$$Q_{um}^{*} = 0.79 Q_f R^{4.2} (D_c / H)^{0.37} \quad [3.4]$$

In practice, the underflow rate is also influenced by the amount of refuse material that reports to the underflow. Therefore, when feed coal is present, the volumetric flow rate of medium to underflow (Q_{um}) is adjusted using:

$$Q_{um} = 0.97 Q_{un} + (Q_{um}^{*})^2 / (Q_{un} + Q_{um}^{*}) \quad [3.5]$$

in which Q_{un} is the volumetric flow rate of nonmedium solids (refuse) reporting to the underflow. In the original model proposed by Wood (1990), Q_{un} is estimated by dividing the dry mass flow rate of refuse obtained from float-sink data by the density of the refuse material. In the present form of the model, an improved iterative approach is used to calculate Q_{un}. In each iteration, the refuse mass rate is recalculated using the partition numbers predicted by the DMC model which, as discussed later, also depends on Q_{um}. The mass flow rates for each density class are divided by their respective densities and the resultant incremental volumes are cumulated to obtain a corrected estimate of Q_{um}. The iterations continue until a steady-state value of Q_{um} is obtained.

The medium split to underflow (S_u) can be obtained from a balance around the cyclone, i.e.:

$$S_u = Q_{um} / Q_{fm} = Q_{um} / (Q_f - Q_{fn}) \quad [3.6]$$

where Q_{fn} = volumetric feed flow rate of non-medium solids. This flow can be readily obtained by dividing the dry coal mass feed rate (M_{fn}) of non-medium solids by the feed coal density (ρ_{fn}). After calculating the medium split to underflow, the density of the underflow medium (ρ_{um}) can be calculated from an empirical relationship given by:

$$\rho_{um} = 0.459 \rho_{fm} S_u^{0.194(\rho_{fm} - 2.04)} P_{RR}^{0.17} H^{0.082} / D_c^{0.182} \quad [3.7]$$

in which P_{RR} is the Rosin-Rammler intercept of the feed magnetite size distribution determined using the laser-diffraction technique (with non-magnetic material removed). The density of the overflow medium (ρ_{om}) can now be obtained from a volume balance which dictates that:

$$\rho_{om} = [\rho_{fm} / (1 - S_u)][1 - S_u(\rho_{um} / \rho_{fm})] \qquad [3.8]$$

b) Partition Factor Calculations

The next step in the simulation of DMC performance is the determination of the partitioning behavior of the feed coal. Unlike previous forms of the model, the current model assumes that the effective sharpness of the separation depends not only on particle size, but also on cyclone diameter. In this case, the Ecart Probables (Ep) for any size class treated by the DMC has been estimated using:

$$Ep = D_c^{0.5} / (398 D_p) \qquad [3.9]$$

in which D_p is the mean particle diameter (in mm) of each size class and D_c is the cyclone diameter (in mm). As shown in Figure 3.19, the present form of the model also assumes that the partition curves for all particle size fractions pass through a common pivot point (Scott, 1988). The pivot point density can be estimated from the empirical expression:

$$\rho_{50}^* = 0.360\rho_{fm} + 0.274\rho_{um} + 0.532\rho_{om} - 0.205 \qquad [3.10]$$

This value represents the effective density cutpoint of an infinitely large particle separated under a zero medium viscosity. The second defining term for the pivot point is obtained at a partition number that is numerically equal to the underflow medium split (S_u). Once the pivot point is identified, the separating density (ρ_{50}) for each particle size class can be obtained using:

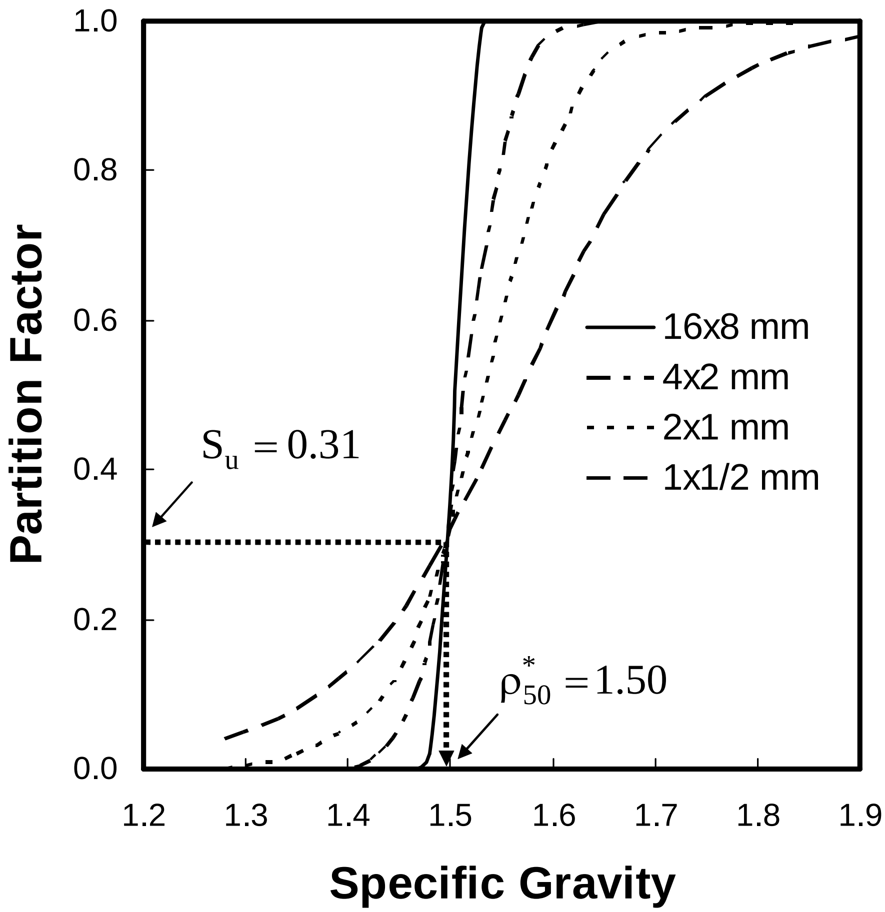


Figure 3.19. Predicted size-by-size partition curves based on the DMC pivot point model (Scott, 1988).

$$\rho_{50} = \rho_{50}^{*} + 0.910 Ep \ln[(1 - S_u)/S_u] \qquad [3.11]$$

Since the ρ_{50} and Ep are now known, the partition number for any size fraction can be estimated from a simplified sigmoid transition function (Whiten equation) given by:

$$P = 1/[1 + \exp\{1.0986(\rho_{50} - \rho)/Ep\}] \qquad [3.12]$$

This equation calculates the probability (P) of a particle of a given density (ρ) reporting to refuse.

c) Operational Checks

The final step in the simulation is to identify any potential operational problems that may limit the accuracy of the predictions. The most important of these include (i) application limits, (ii) clean coal vortex overload, and (iii) particle retention/surging.

Application Limits: Cyclone geometry and flow rates are checked by the simulation routines to ensure that the combination of input variables is acceptable. The model applies to cyclones with the following specifications:

- Cyclone Style = DSM
- Particle Topsize = <0.05 D_c
- Cyclone Diameter = 500-800 mm
- Cyclone Inlet Shape = Square
- Cyclone Inlet Area = $\pi(D_c/10)^2$
- Apex Diameter = 0.3 to 0.4 D_c
- Inlet Head = 6 to 12 D_c of Medium
- Feed Medium Density = 1.2-1.7 SG
- Feed Medium-to-Coal Ratio = >3.0
- Feed Medium Viscosity = 5-20 centipoises

Discrepancies are flagged by the routines so that corrections can be made to the input variables.

Clean Coal Vortex Overload: The flow rate of medium through the vortex finder of the DMC must be sufficient to carry out the larger coal particles present in the feed. If the flow of medium to the overflow is too low, then the excess clean coal cannot be carried through the vortex finder and will instead report to refuse. To avoid this problem, the volumetric medium-to-coal ratio in the overflow should exceed 2.5 (Wood, 1990). If this condition is not met, then the problem is flagged by the simulation routines so appropriate actions can be taken by the user. A corrective action normally necessitates one or more of the following: (i) an increase in inlet pressure, (ii) a decrease in dry feed coal tonnage, and/or (iii) a reduction in apex diameter. Although overloading of the apex is typically not observed in practice, the simulation routines provide a warning flag whenever the medium-to-coal ratio in the underflow drops below 1.5.

Particle Retention /Surging: The classification of magnetite within a DMC causes the density of the underflow medium to be higher than that of the overflow medium. As a result, large middlings particles can be retained within the cyclone when the density difference between the overflow and underflow becomes large. Some of the retained middling will break into smaller particles and report to the appropriate streams due to better liberation and smaller particle size. However, retention can become a problem when middlings particles enter the cyclone at a faster rate than they can be broken or discharged. The excessive build-up of middlings eventually leads to a sudden surge of solids to underflow that often carries a portion of low-density clean coal to the refuse stream. Retention is normally associated with only the coarsest particles and rarely occurs for particles finer than about 15 mm.

Although difficult to predict, the simulation routines provide a warning whenever the medium differential (defined as the difference in the SG between the overflow and underflow) is 0.4 or greater (Wood, 1990). To correct this problem, the user will normally have to change one of more of the following: (i) increase the apex diameter, (ii) lower the cyclone inlet pressure, (iii) use magnetite of a finer grind size, and/or (iv) reduce the top size of the feed material. Unfortunately, some of these corrective actions (such as the use of a larger apex or lower inlet pressure) can create other operational problem such as overloading of the vortex finder.

d) Experimental Validation

An experimental test program was conducted at an operating coal preparation plant to determine whether the predictions provided by the simulation package were acceptable. Representative samples of the feed, clean, and refuse streams from the DMC were collected while the plant was operated at steady-state conditions. The samples were dried, sized, and weighed. Three sizes of the dried solids from each stream were subjected to laboratory float-sink analyses, i.e., 16 x 8 mm, 4 x 2 mm, and 1 x 0.5 mm. The size-by-size data were then used to construct experimental partition curves for the DMC.

Predicted partition curves from the modeling expressions were obtained based on operating information for the DMC circuit. Input values included:

- Feed Rate (Dry Solids)
- Inlet Diameter
- Cyclone Diameter
- Vortex Diameter•
- Apex Diameter
- Inlet Pressure
- Pressure Gauge Elevation (Relate to DMC Axis)
- Feed Medium Density
- Magnetite Rosin-Rammler Intercept

An example of the input data required by the simulation routines is provided in Figure 3.20. A corresponding set of output is provided in Figure 3.21. Based on these values, predicted partition numbers were obtained for each size fraction of the feed coal. The predicted and experimental partition numbers are compared in Figure 3.22. In general, a very good agreement was obtained between the predicted and experimental values. These results suggest that the DMC simulation routines are reasonably reliable.

HEAVY MEDIUM CYCLONE SIMULATION

Description: Example Data Set

	Feed Description	Size Designation	Size (mm) Upper	Lower	Mean	Mass (%)	User SG(50)	Model SG(50)	User Ep	Model Ep	User Bypass
1	Size Class #1	64 x 32 mm	64.00	32.00	45.25	0.09		1.416		0.005	0.000
2	Size Class #2	32 x 16 mm	32.00	16.00	22.63	0.94		1.416		0.005	0.000
3	Size Class #3	16 x 8 mm	16.00	8.00	11.31	2.45		1.417		0.006	0.000
4	Size Class #4	8 x 4 mm	8.00	4.00	5.66	9.02		1.423		0.012	0.000
5	Size Class #5	4 x 2 mm	4.00	2.00	2.83	14.82		1.434		0.024	0.000
6	Size Class #6	2 x 1 mm	2.00	1.00	1.41	16.65		1.457		0.047	0.000
7	Size Class #7	1 x 0.5 mm	1.00	0.50	0.71	24.17		1.503		0.095	0.000
8	Size Class #8	0.5 x 0.25 mm	0.50	0.25	0.35	14.95		1.595		0.190	0.000
9	Size Class #9	0.25 x 0.13 mm	0.25	0.13	0.18	16.91		1.779		0.379	0.000
10											
11											
12											
13											
14											
15											
					Total	100.00					

	User Input	Metric Units		English Units		Warnings/Comments
Mf	Feed Rate (Dry Solids)	162.8	t/hr	179.46	ton/hr	
Di	Inlet Diameter	142.20	mm	5.60	inches	
Dc	Cyclone Diameter	711.00	mm	27.99	inches	
Do	Vortex Diameter	306.00	mm	12.05	inches	
Du	Apex Diameter	218.00	mm	8.58	inches	
P	Pressure	113.76	kPa	16.50	psig	
E	Gauge Elevation (Above HMC Axis)	0.00	mm	0.00	inches	
ρfm*	Feed Medium Density (No Feed)	1.410	SG	1.41	SG	
PRR	Magnetite Rosin-Rammler Intercept	25.000	um	0.0010	inches	

Figure 3.20. Input to the DMC simulation.

HEAVY MEDIUM CYCLONE PERFORMANCE SIMULATION

Simulation Description: Example Data Set

	Operational Information	Override	Metric Units		English Units		Warnings/Comments
Dpmax	Maximum Feed Topsize	---	64.00	mm	2.52	inches	Warning: Topsize may be too large!
Du/Do	Apex/Vortex Diameter Ratio	---	0.71	---	0.71	---	
Du/Dc	Apex/Cyclone Diameter Ratio	---	0.31	---	0.31	---	
Do/Dc	Vortex/Cyclone Diameter Ratio	---	0.43	---	0.43	---	
H	Head (Equivalent Height)	---	8.02	m	26.3	ft	
H/Dc	Head (Equivalent Diameters)		11.28	---	11.28	---	
Qfz	Flow to Feed		343.6	m3/hr	1513	gpm	
Mfm	Medium Mass to Feed	---	334.2	t/hr	368.1	ton/hr	
Qfm	Medium Flow to Feed	---	237.1	m3/hr	1044	gpm	
Qfs	Nonmedium Flow to Feed	---	106.5	m3/hr	469	gpm	
Qus	Nonmedium Flow to Underflow		35.4	m3/hr	156	gpm	
Qos	Nomedium Flow to Overflow		71.2	m3/hr	313	gpm	
rum	Underflow Medium Density		1.599	SG	1.60	SG	
rom	Overflow Medium Density		1.345	SG	1.35	SG	
rfm	Feed Slurry Density		1.447	SG	1.45	SG	
Su	Medium Split to Underflow	---	0.256	---	0.256	---	
So	Medium Split to Overflow	---	0.744	---	0.744	---	
Qum	Medium Flow to Underflow	---	60.66	m3/hr	267.1	gpm	
Qom	Medium Flow to Overflow	---	176.39	m3/hr	776.6	gpm	
Qu	Total Flow to Underflow	---	96.1	m3/hr	422.9	gpm	
Qo	Total Flow to Overflow	---	247.5	m3/hr	1089.9	gpm	
rp	Pivot Density	---	1.411	SG	1.41	SG	
rmin	Lower Retention Density	---	1.402	SG	1.40	SG	
rmax	Upper Retention Density	---	1.51	SG	1.51	SG	
rdif	rmax - rmin	---	0.10	---	0.10	---	
ruo	rum-rom	---	0.25	---	0.25	---	
MCRf	Feed Media/Coal Ratio	---	2.22	---	2.22	---	
MCRu	Underflow Media/Coal Ratio	---	1.71	---	1.71	---	
MCRo	Overflow Media/Coal Ratio	---	2.48	---	2.48	---	

Figure 3.21. Output from the DMC simulation.

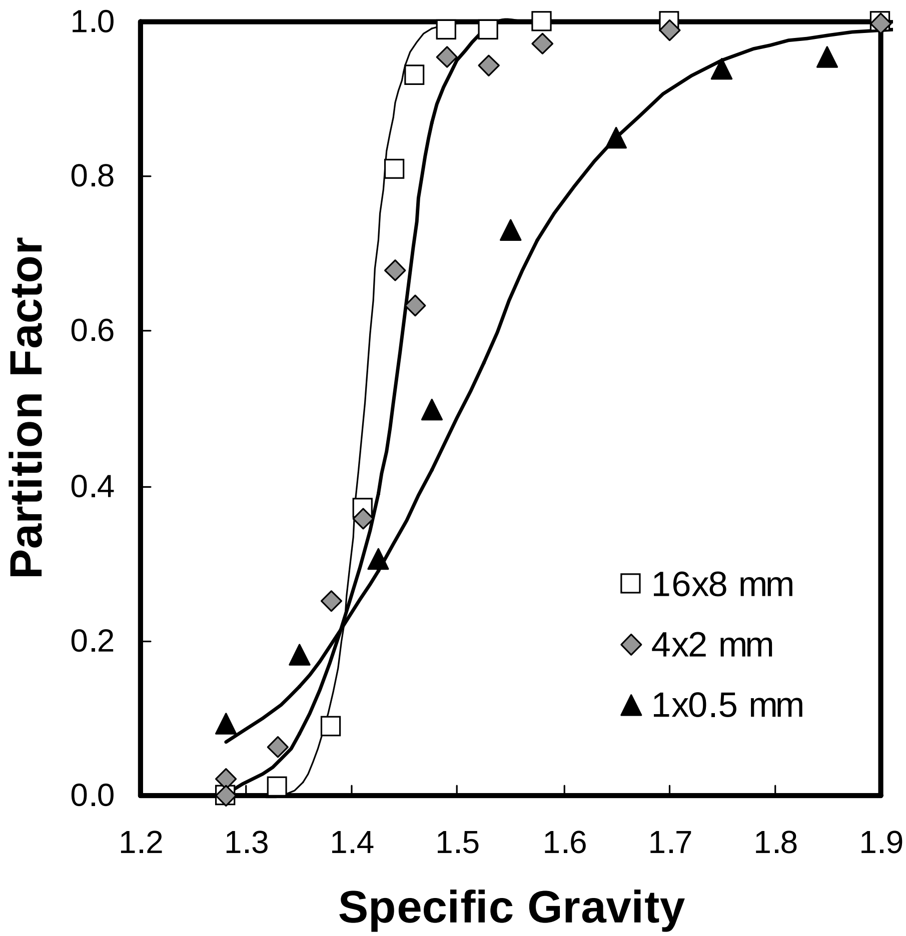


Figure 3.22. Predicted and experimental partition curves for different size factions treated by a DMC bank.

3.3.3 *Expert Advisor System*

The mass balance and simulation routines described previously are useful for designers and engineers. However, plant personnel responsible for monitoring and operating DMCs have the largest impact on day-to-day performance. To this end, an expert advisor package was developed to provide important DMC operating and maintenance guidelines to plant operators. The expert advisor offers a convenient means of transferring expertise from various sources related to performance diagnosis and corrective actions. The expert advisor was constructed using the slide/file hyperlinks in Microsoft PowerPoint. This platform, which is easy to use and modify, provides an interactive graphical interface for visual information including text, images, spreadsheet forms, and audio/video (see Figure 3.23). Examples of a few key recommendations provided by the expert advisor are described in the following sections.

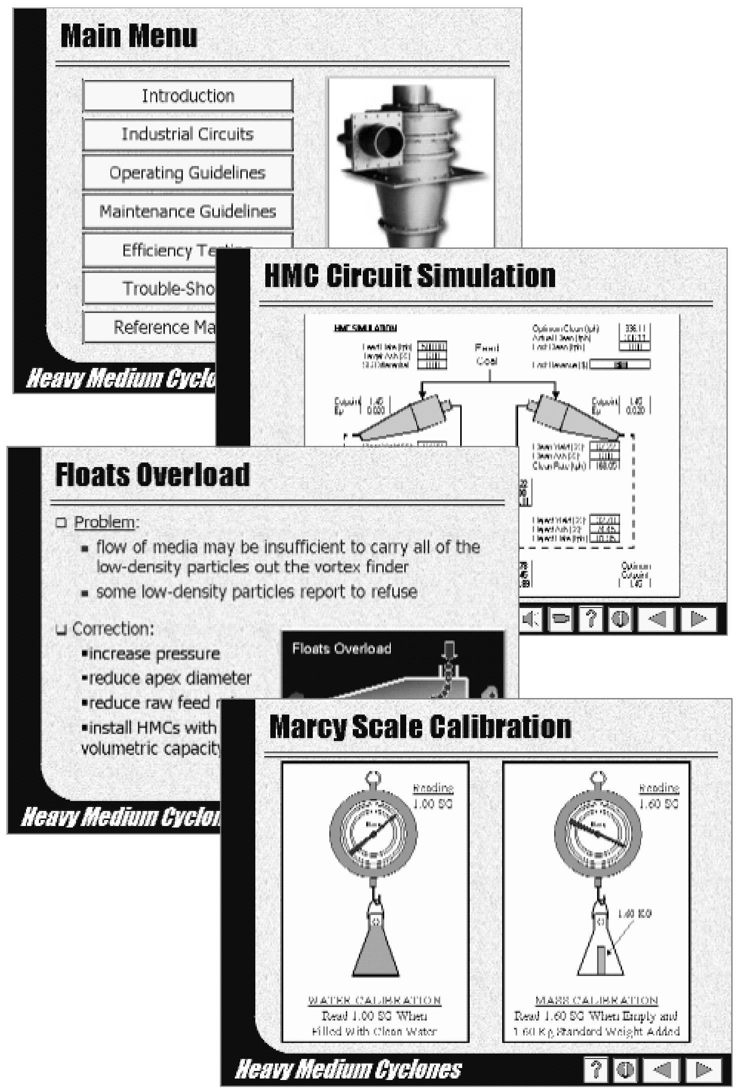


Figure 3.23. Examples of display screens from DMC expert advisor.

Magnetite Size Distribution: The quality of the circulating medium can have a large impact on DMCs. Quality is measured in terms of (i) the size distribution of the medium solids and (ii) the degree of contamination by non-magnetic material. Grade B magnetite (90% passing 325 mesh) is a common choice by U.S. operators. Unfortunately, the circulating medium may be much coarser or finer than the as-received magnetite. Magnetite that is too coarse can become unstable and may lead to a collapse of the dense medium suspension in the cyclone, causing large losses of coal. Magnetite that is too fine is not typically detrimental to performance, although finer magnetite is more difficult to recover in magnetic separators. The particle size distribution of the medium should be routinely monitored by means of electronic particle sizing techniques (e.g., Microtrac) to ensure that the magnetite is of a consistent and acceptable grade.

Medium Contamination: Contamination can adversely impact DMC performance by affecting the medium viscosity and stability. Contamination is usually quantified as the percentage of nonmagnetic fines (<28 mesh) contained in a sample of dried medium solids. The slurry sample is normally passed through a Davis tube to separate the magnetic and nonmagnetic solids prior to drying. To avoid problems created by contamination, the circulating medium should contain less than 7% by weight of non-magnetic solids in the total slurry (excluding any material coarser than 28 mesh). For example, a 1 kg sample of circulating medium (slurry) containing 65 grams (dry) of non-magnetic material would have a non-magnetic contamination level of 65/1000 = 6.5% (contamination is acceptable).

Medium-to-Coal Ratio: Overloading of the vortex finder can cause large coal losses in DMCs. To avoid this problem, the medium-to-coal ratio in the overflow should exceed 2.5 by volume. This condition can be checked by collecting samples of the overflow medium as it discharges from the sieve bend feed box at the top of the sieve. Multiple samples across the entire sieve width and into the full depth of the sieve feed stream must be taken to ensure that the sample is representative. The medium-to-coal ratio (MCR) can then be calculated using:

$$MCR = (M_m / M_c)(\rho_c / \rho_m) \qquad [3.13]$$

where M_m is the mass of sampled medium, M_c the mass of coal solids (plus 28 mesh only), ρ_c the estimated density of the coal solids, and ρ_m is the density of the circulating medium. M_m can be calculated by subtracting the M_c from the total mass of original sample (medium and solids). For example, a sample of slurry from the feed box discharge of a DMC clean coal sieve was collected and found to weigh 45 kg. The slurry sample was screened and found to contain 10 kg of plus 28 mesh solids (dry). The specific gravities of the slurry and solids were found to be 1.4 SG and 1.6 SG, respectively. Based on these values, the medium-to-coal ratio is acceptable since it is greater than 2.5 (i.e., [(45-10)/10][1.4/1.6] = 3.1). If the value is less than 2.5, then the medium flow rate should be increased or coal tonnage reduced.

Medium Split: A minimum of 2/3 of the volume flow of medium that is fed to the cyclone should report to the cyclone overflow. The split can be determined by measuring the cyclone feed density, overflow density (through clean coal sieve), and underflow density (through refuse sieve) and using the formula:

$$\varphi = (SG_u - SG_f)/(SG_u - SG_o) \qquad [3.14]$$

in which φ is the fractional split of medium to the overflow and SG_f, SG_u and SG_o are the specific gravity values for the feed, underflow and overflow, respectively. For example, if the SG of the feed, overflow and underflow are 1.5, 1.4 and 1.7, respectively, then the split to overflow is 2/3 [i.e., (1.7-1.5)/(1.7-1.4) = 2/3] and the split is acceptable. Corrective actions should be taken if the value is less than 2/3. In most cases, a smaller apex can be used to correct an overflow volume that is too small.

Inlet Pressure: Inlet pressure is a key variable that influences DMC performance. Good practice dictates that the inlet pressure should be maintained between 9 and 12 cyclone diameters of medium head. If the pressure is too low (e.g., less than 4-5 diameters of medium head), coal may be misplaced to refuse as the air core becomes unstable and a higher portion of medium splits to underflow. To check for adequate pressure, the DMC should be equipped with an operating and properly calibrated pressure gauge. The required gauge pressure (P_g) can be calculated using:

$$P_g \geq [9D_c \pm E]g\rho_f \qquad [3.15]$$

in which ρ_f is the density of the circulating medium, g the acceleration of gravity, D_c the cyclone diameter, and E is the distance between the pressure gauge and the centerline of the cyclone measured in the inlet area (see Figure 3.24). For example, consider a 60-cm diameter DMC circulating 1.6 SG medium with a minimum of 9 diameters of medium head. A pressure gauge located 95 cm below the centerline of the cyclone should read 100 KPa (i.e., 1.6 gm/cm^3 x 980.6 cm/s^2 (9 x 60 + 95) / 10,000 = 99.6 KPa). At the maximum of 12 diameters of medium head, the corresponding pressure would be 128 kPa

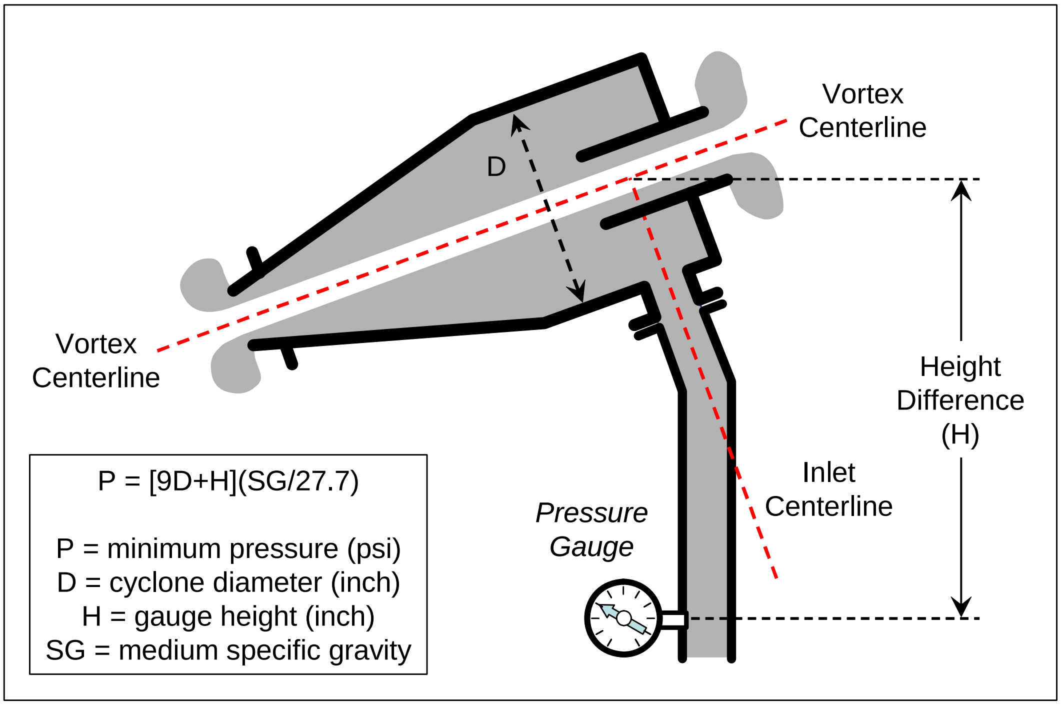


Figure 3.24. Measurement of pressure gauge elevation for a dense medium cyclone.

(i.e., 1.6 gm/cm^3 x 980.6 cm/s^2 (12 x 60 + 95) / 10,000 = 127.9 KPa). Thus, an acceptable pressure gauge reading for this particular configuration would be 100-128 kPa.

Cutpoint Control: All dense medium circuits should be operated at the same SG cutpoints to optimize total plant yield at a given clean coal quality. To avoid differences, all cyclone components (i.e., apexes and vortex finders) on the same bank of DMCs must be of the same size and type. Also, the feed distribution system must be configured so that each cyclone in a bank receives the same flow rate and quality of feed coal and medium. Failure to do so can result in significant losses of clean coal yield. Also, the ability of the operator to maintain the proper SG cutpoint is complicated by the fact that the nuclear density gauges (K-Ray) are not always properly calibrated. To avoid this problem, experimental density readings should be taken using a Marcy scale (or similar device) and compared to the K-Ray readings at the beginning, middle and end of each operating shift.

3.4 Projected Project Benefits

3.4.1 Benefits to the Coal Industry

Tables 3.2 and 3.3 provide an estimate of the potential benefits to the U.S. coal industry that may be achieved due to the successful completion of this project. At present, there are 267 coal preparation plants operating in 16 different states. Current production estimates indicate that these plants are responsible for generating approximately 393 million tons of clean coal annually (36% of the total U.S. coal production). DMCs are used by 220 (82%) of these plants and account for an annual production of 175 million tons of clean coal (16% of the total U.S. coal production). Based on these estimates, a very modest 1 percentage-point increase in efficiency would result in an additional production of approximately 1.75 million tons of saleable coal from the same tonnage of mined coal. The work conducted as part of this project

Table 3.2. Production statistics for DMC circuits.

	Eastern	Central	Western	U.S. Totals
Total Plants	205	43	19	267
Plants with DMCs	172	37	11	220
DMC Feed (ton/yr)	270×10^{6}	60.2×10^{6}	13.8×10^{6}	344×10^{6}
DMC Clean (ton/yr)	135×10^{6}	33.1×10^{6}	6.9×10^{6}	175×10^{6}

Table 3.3. Annual increases resulting from a 1% DMC efficiency improvement.

	Eastern	Central	Western	U.S. Totals
Total Saleable Tonnage	2,699,746	662,558	138,253	3,500,556
Coal Sales Revenue ($)	$67,493,639	$16,563,953	$3,456,316	$87,513,908
Recovered Energy (Btu)	67.5×10^{12}	16.8×10^{12}	3.4×10^{12}	87.7×10^{12}

indicates that a 1 percentage-point improvement is realistically achievable for most plants. The improvement can be obtained through simple modifications to plant equipment and/or operating protocols. At a market price of $50/ton, this additional recovered tonnage represents an increase in annual revenues of more than $87 million for the total coal industry or $398,000 for an average preparation plant. In fact, it is anticipated that more than $22 million of additional revenues could be generated annually if only one-fourth of the U.S. plants implement the DMC optimization procedures outlined in this report.

Although financial incentives provide the primary justification for conducting the proposed work, many other secondary benefits may also be gained by optimization of DMC circuits. For example, the recovery of 1.75 million tons of saleable coal means that the volume of the refuse disposal area can be reduced by this tonnage, thereby reducing the environmental impact of mining. Furthermore, the recovered tonnage represents nearly 200 billion Btu of additional energy each year that can be obtained without additional mining activities. Consequently, this incremental supply of new energy can be gained without new environmental impacts.

3.4.2 Benefits to the Non-Coal Industry

Due to limitations associated with project funding, the completed work focused focus only on coal related applications. However, the expertise developed as a result of this project also has the potential to positively impact non-coal mining industries. At present, many mineral concentration plants in North America utilize density-based separations. Examples of these operations include iron ore, dolomite and potash processing. Dense medium processes are also used by mining companies such as Asarco and Savage Zinc for preconcentration of lead and zinc ores. More recently, companies such as BHP have invested nearly a billion dollars in North America for diamond recovery operations that utilize DMC circuits (Ekati Mine Site). It is also worth noting that many U.S. recycling companies are dependent on dense-medium separations. For example, nearly 80% of U.S. scrap metal is currently separated using dense medium.

Preliminary surveys conducted by the authors of this report indicate that many non-coal applications suffer from the same problems and inefficiencies as coal applications. However, due to the diversity of these operations, it is difficult to estimate the improvements in tonnage and revenue that may be realized by applying the engineering tools developed in this project. The best estimates provided to date suggest that the products from these industries have a value close to that produced by the coal industry. Therefore, the application of the techniques developed here should have a similar economic impact for these industries.

3.4.3 Benefits to Industry Competitiveness

The U.S. mining industry must continue to improve the efficiency of its operations to successfully compete in the global marketplace. Although the mining industry has already made tremendous strides in this regard, most experts agree that further advances may only be achievable through the development of new technologies. Unfortunately, the current economic climate makes it difficult for mining companies to justify spending large sums of capital on new equipment. On the other hand, tremendous incentives exist for the development of new technologies that permit operators to improve the overall efficiency of existing operations. In particular, technologies that allow operators to improve the efficiency of processing plants are very desirable. This is due to the fact that each ton of saleable ore or coal that is recovered through an improvement in plant efficiency adds the full market price of that ton of material to the company revenue. Otherwise, the full market value is lost to waste. Consequently, a 1 percentage point improvement in plant efficiency is roughly equivalent to a 20 percent improvement in profitability for the overall mine. These economics make the optimization strategies developed in this project very attractive.

3.5 Technology Transfer

The near-term commercialization and marketing of engineering tools developed from this project have been undertaken by the participating industrial partners. In particular, Precision Testing Laboratories and Partition Enterprises have a strong financial incentive to promote the products developed and continue this work in the industrial sector. A formal agreement is currently being negotiated between these two groups for servicing the U.S. mining industry with density tracers and engineering expertise related to DMC circuits. The test data collected here provides these parties with the database necessary to persuade industry of the technical benefits and cost advantages of these technologies. To facilitate this process, the academic team member (Virginia Tech) has disseminated information collected from this project throughout the mining industry by means of technical reports, publications, workshops/seminars and professional presentations. A listing of some of the key technical articles and workshops generated as a result of this project are listed below.

a) *Technical Publications*

- Luttrell, G.H., Bomar, T.S., and Wood, C.J., 2002. "Optimization of Heavy Media Cyclone Circuits," Proceedings, SME Annual Conference & Exhibit, Phoenix, Arizona, February 25-27, 2002, Preprint No. 02-128, 7 pp.

- Luttrell, G.H., Bomar, T.S., Wood, C.J., and Bethell, P.J., 2002. "Operating Guidelines for Heavy Media Cyclone Circuits," Proceedings, 19th Annual Coal Preparation Exhibition & Conference, Lexington, Kentucky, April 30-May 2, 2002, pp. 117-124.

- Luttrell, G.H., Barbee, C.J., Wood, C.J., and Bethell, P.J., 2002. "An Industrial Evaluation of Heavy Medium Cyclone Circuits," Proceedings, 19th Annual International Pittsburgh Coal Conference, Pittsburgh, Pennsylvania, September 23-27, 2002, Session 22 – Coal Production and Preparation I, Preprint No. 22-1, 10 pp.

- Luttrell, G.H., Barbee, C.J., Wood, C.J., and Bethell, P.J., 2003. "Operating Guidelines for Heavy-Media Cyclone Circuits," Coal Age Magazine, Vol. 108, No. 4, April 2003, pp. 30-34.

- Luttrell, G.H., Barbee, C.J., and Stanley, F.L., 2003. "Optimum Cutpoints for Heavy Medium Separations," Proceedings, Advances in Gravity Concentration (R.Q. Honaker and W.R. Forrest, Eds.), Density Separations Symposium, SME Annual Meeting, February 24-26, 2003, Cincinnati, Ohio, Society of Mining, Metallurgy, and Exploration, Littleton, Colorado, ISBN 0-87335-227-0, pp. 81-91.

- Luttrell, G.H., Barbee, C.J., Wood, C.W., and Bethell, P.J., 2004. "Simulation of Heavy Medium Cyclone Performance," SME Annual Meeting, Denver, Colorado, February 24-25, Preprint 04-88, 4 pp.

- Barbee, C.J., Luttrell, G.H., Wood, C.J., and Bethell, P.J., 2005. "Simulation of Heavy Medium Cyclone Performance," Minerals & Metallurgical Processing, Vol. 22, No. 1, pp. 38-42.

- Barbee, C.J., Luttrell, G.H., Wood, C.J. and Bethell, P.J., 2005. "Software Tools for Optimizing Heavy Medium Cyclone Circuits," Proceedings, 32nd International Symposium of the Application of Computers and Operations Research in the Mineral Industry (APCOM), March 30 - April 1, 2005, Tucson, Arizona, Preprint No. 095, 7 pp.

b) *Workshops and Short Courses*

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, February 9, 2001, 18 attendees.

- "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, March 9, 2001, 11 attendees.

- "Introduction to Coal Preparation," One-Day Short Course, Sponsored by Coal Prep 2001 Exhibition & Conference, Lexington, KY, April 30, 2001, 66 attendees.

- "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, TECO Coal Company, Dunbar, KY, June 12, 2001, 14 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, July 6, 2001, 10 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, August 17, 2001, 8 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, February 1, 2002, 7 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, February 15, 2002, 13 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, March 1, 2002, 14 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, March 22, 2002, 13 attendees.

- O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, July 10, 2002, 14 attendees.

- "Heavy Medium Cyclones," Half-Day Workshop, Coastal Coal Company, Kingwood, WV, planned for October 23, 2002, 12 attendees.

- "O&M Guidelines for Heavy Medium Cyclone Circuits," Half-Day Workshop, Alpha Natural Resources, Abingdon, VA, December 10, 2003, 19 attendees.

CONCLUSIONS

The full capabilities of dense medium cyclones are often not realized in industrial practice due to poor design and improper circuit layout. In addition, dense medium cyclones are often not operated under optimum conditions due to a shortage of trained operators and a lack of accepted guidelines for operation and maintenance. To help overcome these problems, engineering tools were developed to assist coal producers in monitoring and optimizing the performance of their DMC circuits. These tools include (i) low-cost density tracers that can be used by plant operators to rapidly assess DMC performance, (ii) mathematical process models that can be used to predict the influence of changes in operating and design variables on DMC performance, and (iii) an expert advisor system that provides plant operators with a user-friendly interface for evaluating, optimizing and trouble-shooting DMC circuits.

The field data required to develop the engineering tools for DMC optimization was collected via detailed sampling and evaluation programs for seven different DMC circuits at five different plant locations. The field tests showed that partitioning data easily generated using synthetic density tracers, combined with simple measurements of feed, overflow and underflow medium densities, make it possible to estimate the size-by-size partition curves for coal particles. The accuracy of these predictions rivals that of curves developed using conventional, expensive and time-consuming procedures based on laboratory float-sink analyses.

The partition data for the various DMC circuits showed that with the exception of one site (Plant D), there was no gross misplacement of coal or rock particles with densities remote from the cutpoint. The separation efficiencies, in terms of sharpness of partition curves, were generally fair-to-good for all seven circuits. However, there was potential for yield increase by better matching of SG cutpoints with other circuits in many of the plants. A review of plant operating and maintenance (O&M) practices indicated that the key reasons for these generally good results were largely due to (i) prompt replacement of worn components to maintain similar dimensions of DMCs operating in parallel, (ii) recent increases in DMC inlet pressures into the recommended ranges identified by the investigators, and (iii) a management policy to operate all circuits, wherever and whenever possible, at high SG cutpoints to reduce the sensitivity of yield to partitioning inefficiencies.

Some design problems were identified and addressed during the test program. For example, the layouts of the DMC circuits at Plants C and E and of the primary DMC circuit at Plant B experienced major problems in monitoring of feed medium density. Appropriate steps in terms of new equipment purchases and improved measurement protocols were taken at all sites to allow accurate monitoring of this fundamentally important parameter.

Several software tools were also developed as part of this project to assist plant operating in the day-to-day operation and maintenance of their DMC circuits. These user-friendly tools include (i) a mass balancing routine for analyzing test data, (ii) a spreadsheet-based simulation model for predicting separation performance, and (iii) an expert advisor for trouble-shooting common operational problems. Experimental data collected from industrial DMC installations suggest that these tools can indeed be successfully used to optimize the performance of DMC circuits.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support for this work provided by the various industrial participants involved in this project. This work would have not been possible without their dedication, hard work and valuable assistance. In addition, sincere gratitude is expressed to the numerous graduate students at Virginia Tech that contributed to the data collection activities associated with this project. External funding for this project was provided by the U.S. Department of Energy under Award No. DE-FC26-01NT41061 (Industries of the Future Program).

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APPENDICES

APPENDIX I - Detailed Follow-Up Reports

APPENDIX I-A

Detailed Follow-Up Reports
Plant Site A

FINAL PLANT ASSESSMENT REPORT
"DENSE MEDIUM CYCLONE OPTIMIZATION"

REPORT FOR PLANT SITE "A"

Project Period:

December 14, 2000 – December 30, 2004

DOE Project Number:

DE-FC26-01NT41061

Participating Organizations:

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Mining & Minerals Engineering
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Massey Energy Company
315 70th Street
Charleston, West Virginia 25304

1. INTRODUCTION AND OBJECTIVES

This study was conducted as part of the project "Dense Medium Cyclone Optimization" funded by the US Department of Energy. Team members are:

- Virginia Polytechnic Institute and State University
- Massey Coal Services
- Partition Enterprises Pty Ltd
- Precision Testing Laboratories

Objectives were:

- to determine whether useful performance data and performance estimates for all sizes can be quickly generated using density tracers supported by other on-the-spot observations including Marcy measurements of the densities of feed, overflow and underflow medium,
- to compare such estimates with the results of conventional float/sink analyses which are much more time-consuming and expensive, and
- to use the tracer results to identify any inefficiencies and develop recommendations for corrective actions.

If the density tracer technique with its rapid results and low cost is demonstrated to be useful in maximizing and maintaining yields, it could become a valuable adjunct to, or partial replacement of, conventional float/sink testing.

2. THE CIRCUIT AND FEED COAL

The plant incorporates a heavy medium vessel for coarse coal. Minus 1.25 inch plus 14 mesh coal is treated in a bank of five heavy medium cyclones. DMC capacity has been increased by the addition of a "fine coal DMC circuit" to share some of the load of minus 0.5 inch material. Fine coal is treated by spirals and flotation. All circuits contribute to a common product. Key aspects are generally as detailed in the Powell Construction Company flowsheet (Drawing No 2821-FS1).

2.1 Coarse Coal DMCs

Because access was limited, deslime screen oversize was not sampled. However, timed samples of primary clean coal and refuse were recovered. Properties of reconstituted feed were determined as follows:

plus 16mm (0.63")	30%
plus 31.8mm (1.25")	<5% (by extrapolation)
minus 0.5mm (28 mesh)	0.5%

These figures are in line with the design, and the final figure indicates excellent desliming in spite of spray water flows which appeared rather low.

The flowsheet was based on Powellton seam coal with a plant feed rate of 2200 long t/h. The reporting basis (as-received, dry, etc.) was not indicated. During the test period, plant feed rate averaged 2282 long t/h (as received). The dry basis rate would have been close to 2200 long t/h. As shown in Table 1, load on the DMCs was around 80% above design, but yield was low. As will be shown, a contributor to the low yield is the fact that the cutpoint was lower than expected. However, it is clear by comparison with the design that there was more coal in this size range and a very large proportion of rock.

Table 1.
Coal Flows and Yield in the Coarse Coal DMC Circuit

Stream	**Design** Powellton long t/h	**Estimated** White Knight / Hernshaw long t/h
DMC Feed	444	814 (reconstituted)
DMC Product	289	353
DMC Rejects	155	461
Yield	65%	43%

Unlike DMC circuits in some plants, the nucleonic medium density gauge is well located on a medium line from a head box (without coarse coal). A draft-tube sump and pump feed a long vertical pipe run into a symmetrical 5-way distributor (Figure 1) ahead of the five DMCs. There appears to be some inconsistency in numbering of the DMCs. Overflow from four DMCs is directed to one box with outlets to four drain-and-rinse screens, while that from the fifth DMC reports to a single box fitted with a discharge line to the fifth screen; however, there is a connecting pipe between the two boxes. A somewhat similar arrangement distributes the five underflow streams between four refuse screens. In these circumstances, performances of individual DMCs cannot be determined or inferred and we are compelled to treat the bank of five DMCs as a single separator.

Medium bleed for density and sump level control is taken from the correct medium head box (not directly from the drain section of clean coal or refuse sieve bends and screens). Thus, it is representative of DMC feed medium and is relatively unbiased in respect to the concentration and size distribution of magnetite or of non-magnetic contaminants.

Figure 1.
The five coarse coal DMCs are fed via a distributor. The lines from the distributor to the cyclones are not symmetrical but their pressure drops would be similar. The distributor itself is well configured with a long vertical feed line and symmetrically-arranged outlets.

Assessment of the timed samples showed that loadings on the clean coal and refuse screens varied considerably from screen to screen. Of the five clean coal screens, #4 treated 13% of the load while #5 treated 27%. Of the four refuse screens, #4 treated 17% and #2 treated 34% of the load. However, due to the DMC overflow and underflow box configurations described above, these figures are not reliable guides to loadings on individual DMCs.

Water sprays on the desliming screens were rather gentle. Flows and distributions of rinse water on the drain-and-rinse screens were generally good (Figure 2).

2.2 Fine Coal DMCs

In the case of the fine coal DMCs it was feasible to sample all deslime and drain-and-rinse screens. The circuit feed contained only 1.3% plus 16 mm (0.63”) and 2.5% minus 0.5mm (28 mesh). This fits with the nominal size range of –0.5 inch +28 mesh and the desliming is shown to be effective in spite of the absence of rinse sprays. Table 2 shows the design and estimated coal flows. In this case, the observed feed rate is close to the design value, but again the yield is lower than designed.

Figure 2.
Spray water on drain-and-rinse screens was plentiful and generally well-distributed though, in this case, one apex was blocked.

Table 2.
Coal Flows and Yield in the Fine Coal DMC Circuit

Stream	**Design** Powellton long t/h	**Estimated** from timed samples White Knight / Hernshaw long t/h
DMC Feed	444	453
DMC Product	289	253
DMC Rejects	155	199
Yield	65%	44%

Also, in this circuit the nucleonic medium density gauge is well located on a correct-medium line (without coarse coal). A single wing-tank and pump feed a pipe run into a symmetrical -way distributor (Figure 3) ahead of the three DMCs. The figure shows that, in this case, there is a bend of nearly 90 degrees immediately ahead of the distributor. Such a configuration is likely to cause segregation of coal, rock and magnetite. This can bias the feed between DMCs, perhaps causing some to be overloaded and/or to have different cutpoints than others.

Figure 3.
A bend in the line to the distributor which feeds the three fine coal DMCs may be expected to induce feed biases. Surprisingly, it did not cause the DMCs to have different cutpoints, but it may limit capacity for efficient partitioning.

Overflows from the 3 DMCs are collected in a single box with outlets to three clean coal drain-and-rinse screens. Underflows are also collected in a single box with outlets to two refuse screens (which are followed, in series, by two more refuse screens). Again we are compelled to treat the bank of three DMCs as a single separator.

As with the coarse coal DMC circuit, the medium bleed should be representative of the overall circulating medium. Prior to this study, a mixing box was retro-fitted to ensure this, though the author did record a couple of anomalous readings.

For this circuit the loadings across clean coal or refuse screens were more consistent than in the coarse coal circuit, but again, this gives little guidance as to loadings on the three individual DMCs.

The two desliming banana screens have no water sprays. Flows and distributions of rinse water on the drain-and-rinse screens were generally good.

3. DMC DIMENSIONS AND CONDITION

3.1 Coarse Coal DMCs

The five coarse coal DMCs are 28 inch Deister units. Number 2 carries the nameplate "DCY27.28B.20FB." All cyclones have ceramic internals, but there are variations in the numbers of components and in the ceramic form. Cyclone 3, for example, is fully tiled. The others have at least some components of monolithic ceramic (Figure 4). Components were in generally good condition without severe wear.

At the points where they meet, component IDs did not always match and some were slightly misaligned. This results in inward or outward "steps" (Figure 5). Inward steps can be disruptive to flow, affecting partitioning performance and inducing localized wear (Figure 6). Number 5 had the largest inward "step," approximately 10 mm (3/8").

All cyclones were fitted with a parallel (cylindrical) section at the underflow discharge. The author considers this to be a valuable feature in that it greatly reduces the rate of wear at the apex, maintaining the critical apex diameter within an acceptable range over a much longer period.

The apexes had not worn seriously out-of-round, the largest and smallest diameters of any one apex varying by no more than 3mm (1/8"). Mean apex diameters ranged from 218 mm (8.58") for number 3 to 227 mm (8.94") for numbers 1 and 2. For cyclones of this configuration, the author would expect that difference to cause cyclone 3's cutpoint to be about 0.03 SG units higher than that for cyclones 1 and 2.

Figure 4.
A coarse coal DMC viewed from the apex end. The white ceramic ring is the parallel section below the actual apex. The white tiles around the edges of the figure constitute the shroud. (The wear groove in the shroud does not affect partitioning.)

Figure 5.
A closer view of a coarse coal DMC. The parallel section is constructed of long tiles. An outward “step” is visible at the joint from apex to parallel section. At the next joint there is an outward “step” from 1 o’clock to 6 o’clock and a corresponding inward “step” (not clearly visible) from 6 o’clock to 1 o’clock. More careful alignment of components would almost eliminate those “steps.”

Figure 6.
In this view of a coarse coal DMC an outward “step” appears to have induced localized wear of the downstream component – especially around 4 o’clock and 10 o’clock.

3.2 Fine Coal DMCs

The three fine coal DMCs were Krebs D30B-T215 units. A Krebs engineer advised that the components supplied to Plant A include 50 square inch inlets and vortex finder IDs of 14 inches. At nine “cyclone diameters” the throughput should be 2240 gpm.

The three units are of identical construction with all tiled components except the lower cones and apexes which are monolithic ceramic. They were in generally good condition with small "steps" in the range of in 5 mm to out 5 mm (Figures 7 and 8). The condition of components was generally good but there was localized wear of the apexes adjacent to the flanges where they fit to the lower cones. Apexes were in good condition and almost round. Inside diameters were 11.5, 11.6 and 11.5 inches. Unusually, the vortex finders are fitted with discharge shrouds which appear to be somewhat restrictive (Figure 9).

Figure 7.
Internals of this fine coal DMC are in good condition and are reasonably well aligned.

Figure 8.
Apex and shroud of a fine coal DMC. An outward "step" is visible just upstream of the apex. Such "steps" induce localized wear of the apex as was evident in two of the three fine coal DMCs.

Figure 9.
Shrouds on the fine coal DMC vortex finders appear restrictive. Their bases and discharge ends are understood to be open, but they may limit flow from that orifice, potentially reducing cutpoint and limiting the capacity to discharge floats.

4. OPERATING PRESSURE

For the coarse coal DMCs, operating pressure is monitored by an electronic transducer. Calibration or test information on the latter could not be obtained, but such units are usually reliable. During the test period the pressure was recorded as 16.5 psi +/- 1 psi. Making due allowance for the transducer location, the DMC diameter and the estimated slurry density, this converts to a pressure head, as defined by Dutch State Mines personnel in the 1940s, of 10.5 “cyclone diameters” of medium. This is precisely in the middle of the range of 9 to 11 “diameters” usually recommended by the author.

Due to an equipment malfunction, pressure for the fine coal DMCs was not being monitored at the time of these trials.

5. MEDIUM DENSITY MONITORING AND CONTROL

As detailed in Section 2 (and unlike some plants) both DMC circuits have well-located K-Rays and provision to recover Marcy samples of circulating medium without coal.

The Marcy gauge in use was of the balance-beam type, as distinct from the dial type. The the former suffers from the following shortcomings in comparison to the dial type.

- They are difficult to adjust (e.g. if a new flask of different tare mass is used).
- Their readability is usually poor in that the scale divisions are usually small.
- The operator needs to judge if the beam is horizontal.
- Adjustment of the slide weight can cause spillage from the flask.

In this case, it also seems likely that the flask was not of the correct volume.

Thus, there may have been an offset in all medium density measurements and this may account, in part, for the unusually small offsets between medium densities and cutpoints (Section 6). The effect of an offset on the medium split calculations (Section 7) would be small.

During the test period, medium density control loops were effective in that the K-Ray signal deviations from cutpoint:

- for the coarse circuit were less than 0.01 SG units (2 minute average), and
- for the fine coal circuit were up to 0.01 SG units (2 minute average).

6. DENSITY TRACER TESTS AND RESULTS

6.1 Coarse Coal DMCs

Cubic density tracers of 32 mm edge length were used. A preliminary or "sighting" test was conducted first using only five tracers at each of a wide range of densities. As the SG range of interest was quickly defined, the exercise was converted to a full test by the addition of a further 35 tracers at each of the SGs of principal interest. Results, together with other key observations, are presented in Table 3. Coal sampling was conducted immediately following the tracer test.

The vortex finders of four DMCs discharge into a common box which feeds four drain-and-rinse screens. The fifth vortex finder feeds a second box, but a large pipe joins both boxes. The apexes discharge into a common box which feeds four drain-and-rinse screens. In these circumstances, the module must be treated as a single separator, and no reliable conclusions can be drawn as to the comparative performances of individual DMCs.

For similar reasons, the discrepancies between loadings on individual screens cannot be seen as evidence of bias in the feed to individual DMCs.

The partition curve shows that there was no gross misplacement of float 1.36 SG material to refuse or of sink 1.46 SG material to product. However, two issues call for comment:

- The apparent cutpoint was only 0.01 SG units higher than the feed medium density. In view of the appropriate pressure and the observed relationship between feed, overflow and underflow medium densities, this is surprising. It may relate to possible inaccuracy of the Marcy gauge used at that time or to the high loading of rock.

- The observed Ep of 0.013 is poor; an individual DMC is capable of partitioning these tracers with an Ep of only 0.005 SG units. It is likely that individual units were separating at slightly different cutpoints due to feed biases or, more likely, to the different apex sizes.

6.2 Fine Coal DMCs

The fine coal DMCs were tested on the same day using both 32 mm and 16mm tracers. From these three DMCs, overflow discharges into a common box, as does the underflow. As with the coarse coal DMCs, the three fine coal units must be treated as a single separator.

Results for 32 mm tracers are presented in Table 4. The 16mm tracers generated a nearly identical partition curve. When the project was in the planning stage, it was considered that only high-cutpoint circuits would be assessed. Consequently, the stock of density tracers encompassed only three densities below 1.40 SG. Thus, the partition curve is not defined with the degree of detail one might desire.

Again there was no misplacement to refuse of particles at SGs below 1.36 and, this time, no misplacement to product of particles at SGs greater than 1.42 SG. Indeed, only at 1.40 SG was the observed partition number intermediate between 0 and 100% to underflow. The Ep value was probably close to the value of 0.005 as drawn on the test sheet.

Partitioning efficiency left little to be desired, but again the cutpoint was surprisingly low at nearly 0.04 SG units below the feed medium density. Again, the feed, overflow and underflow medium densities suggest that this should not be the case. The fault may lie with the accuracy of the Marcy gauge or with a bias at the feed medium sampling point.

Table 3

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

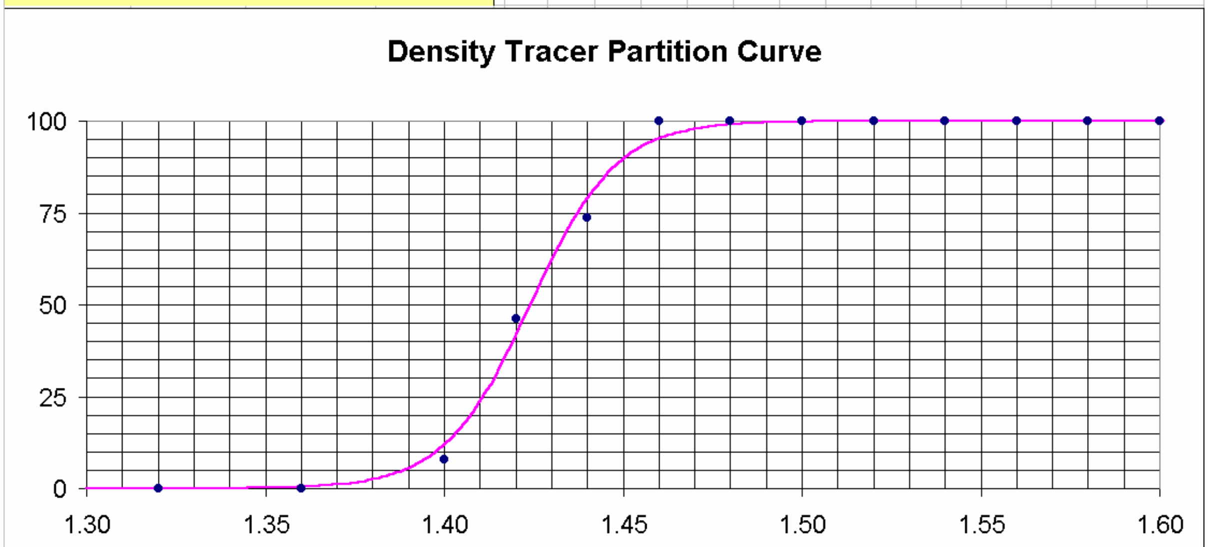
Test ID	Module ID	Date	Time
Elk Run	Coarse DMCs	June 19, 2001	11:55 to 12:30 approx
Feed Type	Plant Feed tph	Circ Feed tph	Tracer Size
70 White Kn (P) 30 Hernshaw	2280	814	32
Diameters of (inches)	Body	Vortex Finder	Apex
	28	XXXXXXX	9.0
Condition of	Bodies	Vortex Finders	Nozzles
	good	good	good
Apex Alignment	Inlet Pressure	Gauge Posn	Head
fair/good	16.5 psi	29 in below inlet	10.5 diameters
Magnetite	Feed RD	Overflow RD	Underflow RD
	1.41	CC1 1.34	Ref1 1.60
		CC2 1.34	Ref2 1.59
		CC3 1.35	Ref3 1.61
		CC4 1.345	Ref4 1.595
		CC5 1.35	

Other Operating Conditions / Observations

Nucleonic gauge reading CHECK WITH SHANE

Mean nozzle diameters ranged from 8.58 to 8.94 inches.

R D	Number of Tracers . . .													**% to**
	in	retrieved from...											Recov	**U/flow**
	Feed	Overflow						Underflow					ered	
		unit	unit	unit	unit	unit	Total	unit	unit	unit	unit	Total	b+c	
	a	1	2	3	4	5	b	1	2	3	4	c	d	
1.32	40	11	5	8	3	11	38	0	0	0	0	0	38	0
1.36	40	8	8	4	6	9	35	0	0	0	0	0	35	0
1.40	40	7	8	8	2	10	35	1	0	2	0	3	38	8
1.42	40	4	3	5	4	5	21	4	7	5	2	18	39	46
1.44	40	1	2	1	3	3	10	9	12	3	4	28	38	74
1.46	40	0	0	0	0	0	0	13	12	6	6	37	37	100
1.48	40	0	0	0	0	0	0	10	11	11	6	38	38	100
1.50	40	0	0	0	0	0	0	8	15	6	9	38	38	100
1.52	40	0	0	0	0	0	0	14	10	7	8	39	39	100
1.54	5	0	0	0	0	0	0	1	1	1	2	5	5	100
1.56	5	0	0	0	0	0	0	2	2	1	0	5	5	100
1.58	5	0	0	0	0	0	0	3	0	0	2	5	5	100
1.60	5	0	0	0	0	0	0	1	0	2	2	5	5	100
1.62	40	0	0	0	0	0	0	11	17	5	5	38	38	100
1.64	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.66	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.68	5	0	0	0	0	0	0	2	1	2	0	5	5	100
1.70	5	0	0	0	0	0	0	3	2	0	0	5	5	100
Known dropped														
		0	1	0	1	1		0	2	0	1			



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30:**	**nil**	**Cutpoint:**	**1.42**	**Ep:**	**0.013**

Table 4

PARTITION ENTERPRISES PTY LTD
P.O. Box 512, Indooroopilly, Queensland 4068, Australia. **Tel: +61 7 32781614 Fax: +61 7 33792375**

Density Tracer Test Sheet

Test ID	Module ID	Date	Time
Elk Run	Fine DMCs	June 19, 2001	15:00 to 15:32
Feed Type	Plant Feed tph	Circ Feed tph	Tracer Size
70 White Kn (P)	2130	453	32mm
30 Hernshaw			& 16mm
Diameters of	Body	Vortex Finder	Nozzle
(in)	30	14	11.6
Condition of	Body	Vortex Finder	Nozzle
	good	good	fair
Apex Alignment	Inlet Pressure	Gauge Posn	Head
fair	no pressure gauge	33 in below inlet	cannot determine
Magnetite	Feed RD	Overflow RD	Underflow RD
	1.43	CC1 1.33	Ref1 1.59
		CC2 1.32	Ref2 1.61
		CC3 1.32	

Other Operating Conditions / Observations

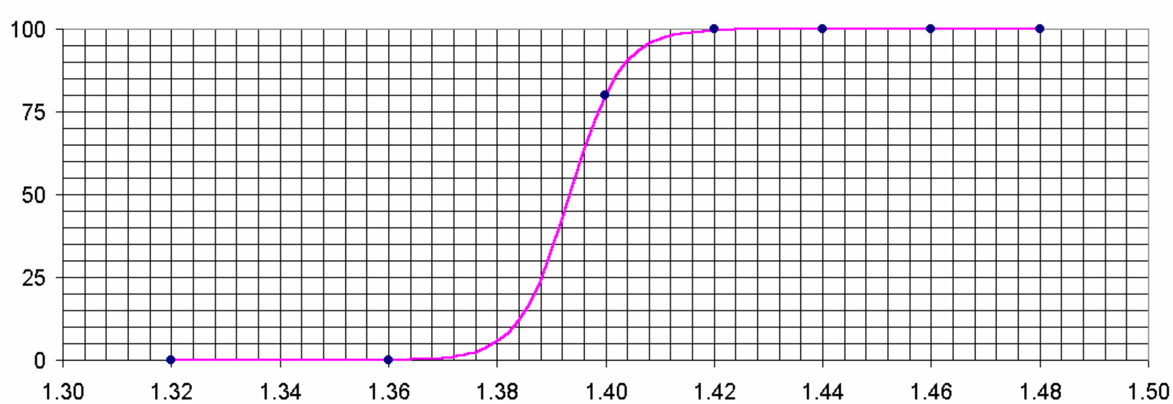
Nucleonic gauge reading 1.38
Mean nozzle diameters were 11.54, 11.63 and 11.52 inches.
16mm density tracers gave a partition curve almost identical with this curve from 32mm tracers.
CHECK MARCYS WITH SHANE

Basis for Calculation (choose one)	**% to U/flow**
If losses are:	
<10%, some from o/flow & some from u/flow	c/d **- used**
significant from u/flow & negligible from o/flow	(a-b)/a
significant from o/flow & negligible from u/flow	c/a

32 mm

R D	Number of Tracers . . . in Feed	retrieved from... Overflow unit 1	Overflow unit 2	Overflow unit 3	Overflow Total	Underflow unit 1	Underflow unit 2	Underflow unit 3	Underflow unit 4	Underflow Total	Recovered b+c	**% to U/flow**
	a	1	2	3	b	1	2	3	4	c	d	
1.32	20	3	6	11	20	0	0	0	0	0	20	0
1.36	20	4	10	5	19	0	0	0	0	0	19	0
1.40	20	1	2	1	4	11	5	0	0	16	20	80
1.42	20	0	0	0	0	12	5	0	1	18	18	100
1.44	20	0	0	0	0	10	9	0	1	20	20	100
1.46	20	0	0	0	0	10	7	0	2	19	19	100
1.48	20	0	0	0	0	16	4	0	1	21	21	100
Known dropped		0	1	0		0	2	0	1			

Density Tracer Partition Curve



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30:**		**Cutpoint:**	**1.39**	**Ep:** **0.005**

7. SIZE-BY-SIZE PERFORMANCE

7.1 Predicted from Density Tracer Results and Medium Behavior

7.1.1 Introduction

The partitioning behavior of coal particles larger than about 8 mm may be expected to approximate that of the 32 mm tracers. To predict the partition curves for smaller particles we will utilize the observation that there is a strong tendency for all the curves to pass through or close to a "pivot point" which occurs at a partition number tending to match the volumetric fraction of medium which reports to DMC underflow.

There is a strong phenomenological basis for this behavior which arises from the following points which relate to a DMC operating with a truly stable medium:

- There is no tendency for particles of density equal to the medium density to report preferentially to overflow or to underflow. Thus they are partitioned according to the volumetric split of medium.
- Due to fluid drag phenomena, very small particles (of any density) are also partitioned according to the volumetric split of medium.
- For particles of a density not equal to the medium density, the partition number for a small particle will be closer to the medium split than that for a large particle. This also relates to fluid drag and explains why Ep values increase with decreasing particle size.

Of course, particulate medium such as slurries of magnetite in water are never truly stable, and the author usually estimates the volumetric split of medium by measuring the densities of feed, overflow and underflow medium and invoking the formula:

$$Volume\ \%\ to\ Underflow = 100\frac{Feed\ \ Medium\ SG - Overflow\ Medium\ SG}{Underflow\ Medium\ SG - Overflow\ Medium\ SG}$$

7.1.2 Coarse Coal DMCs

In this case:

$$Volume\ \%\ to\ Underflow = 100\frac{1.41-1.35}{1.60-1.345} = 25\%$$

A DMC performance model developed by the author (Wood, 1991) suggests that, except at exceptionally low pressures or exceptionally high medium viscosity, a single DMC can achieve the rather small size-by-size Ep values listed in Table 5. For "real-world" situations, which account for internal roughness of DMCs and the inaccuracies of float/sink analyses, these are increased by 50 percent and, for the Plant A coarse circuit, they are further degraded by an addition of 0.01 to account for the observed differences in apex diameters.

These considerations give the cutpoints and Ep values listed in Table 5 and illustrated in Figure 10. Cutpoint for the coarse fraction is assumed to be similar to that for 32 mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 25% to underflow.

Table 5.
Coarse Coal DMCs
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model x1.5 SG units	Predicted for Plant A Coarse DMCs from tracer test (see text) SG units		Observed for Plant A Coarse DMCs based on float/sink SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.005	1.42	0.015	1.42	0.02
-4 +2	2.8	0.020	1.44	0.03	1.43	0.04
-1+0.5	0.7	0.078	1.50	0.09	1.50	0.08

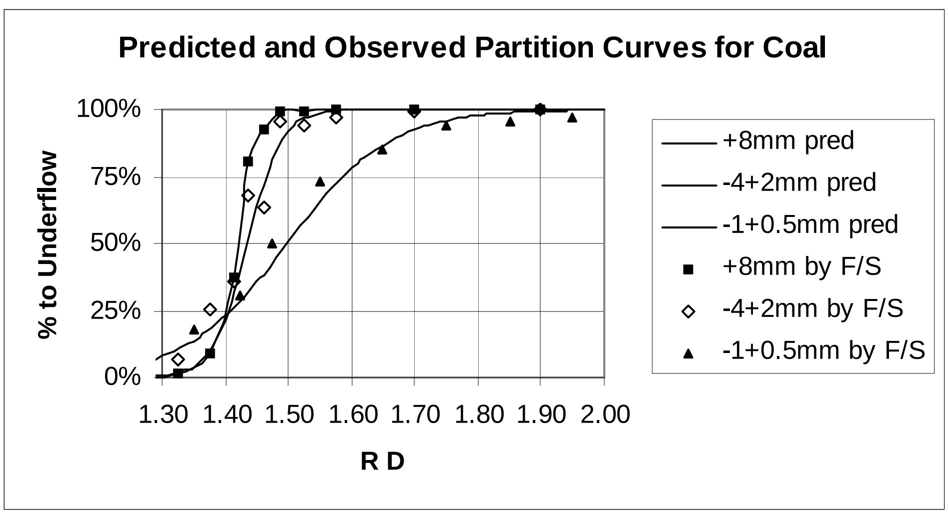


Figure 10.
For the coarse coal DMCs, partition points derived by float/sink procedures fell almost precisely on the curves predicted from density tracer results and medium density measurements.

7.1.3 Fine Coal DMCs

In this case:

$$Volume\ \%\ to\ Underflow = 100\frac{1.43-1.323}{1.60-1.323} = 39\%$$

Again, the model Ep values are increased to account for factors such as internal roughness and float/sink inaccuracies. Because apex diameters are similar and the tracer curve shows good performance in spite of the potential feed biases, no further degradation is applied to the Ep values.

Predicted cutpoints and Ep values are listed in Table 6 and illustrated in Figure 11. Cutpoint for the coarse fraction is assumed to be similar to that for 32 mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 39% to underflow.

Table 6
Fine Coal DMCs
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model x1.5 SG units	Predicted for Plant A Fine DMCs from tracer test (see text) SG units		Observed for Plant A Fine DMCs based on float/sink SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.005	1.39	0.005	1.39	0.005
-4 +2	2.8	0.020	1.40	0.02	1.39	0.02
-1+0.5	0.7	0.078	1.42	0.08	1.42	0.07

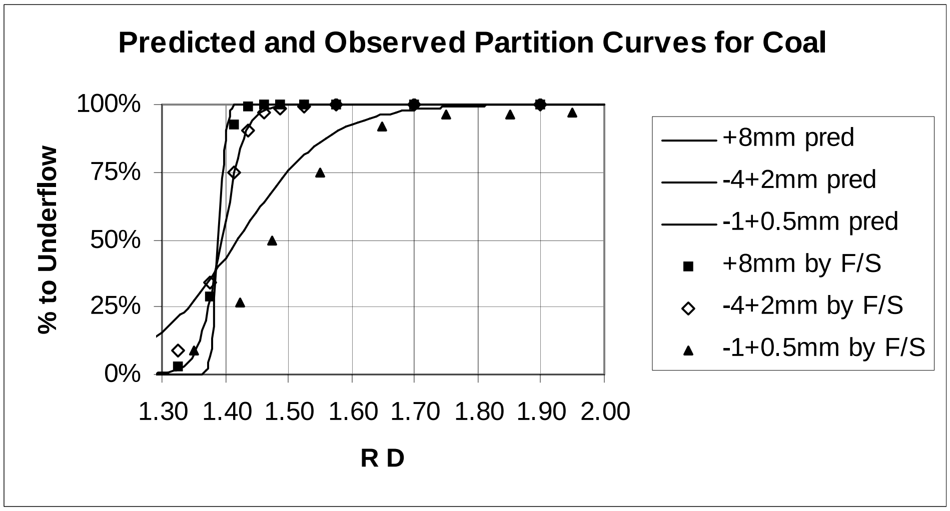


Figure 11.
For the fine coal DMCs, partition points derived by float/sink procedures fell close to the curves predicted from density tracer results and medium density measurements. In the case of the finest fraction, -1+0.5mm, there was a significant departure. Possible causes include errors in medium density measurements, particle degradation during sampling and processing and errors inherent in float/sink procedures for fine particles.

7.2 Comparison of Predicted Partition Curves with Float/Sink Results

In conjunction with the tracer tests, coal samples were also recovered and their analyses have recently been completed. Those data have been used to generate partitioning results for three size fractions of coal. Derived parameters (cutpoint and Ep values) are included in Tables 5 and 6. Figures 10 and 11 show comparisons between the partition curves predicted from the tracer test results and the actual float/sink partition points.

For the coarse coal DMCs the predicted and observed partition points are almost identical. For the fine coal DMCs there is some discrepancy for the finest size fraction. A possible reason alluded to in the caption of Figure 11 relates to errors in measurements of medium densities (which are used to estimate the volumetric split of medium to underflow). There is some doubt as to the accuracy of those measurements because the volume of the Marcy flask appeared not to be exactly 1 liter and the Marcy scale was of the balance-beam type. These have relatively poor readability and are difficult to calibrate.

Overall the tracer-derived predictions are considered to be excellent.

8. POTENTIAL FOR YIELD IMPROVEMENT

8.1 Optimizing Partitioning Precision of the DMCs

It is likely that the Ep value for each size fraction in the coarse coal DMCs could be reduced by approximately 0.01 SG units if all apex pieces were of the same diameter.

The fine coal DMCs were partitioning with excellent precision.

The potential for yield improvement will be estimated by simulation.

8.2 Matching Cutpoints of Vessel, Coarse DMCs and Fine DMCs

At Plant A the vessel, coarse coal DMCs and fine coal DMCs contribute to a common product. For a given product quality, yield is maximized if all three circuits operate at equal incremental ash. (The incremental ash is defined as the ash content of additional product recovered when a circuit – with its non-zero Ep – is caused to recover just a little more product). If the separators are high-efficiency units, as heavy medium separators usually are, that condition is approximated if all circuits are caused to operate at equal cutpoints.

At the time of these tests the coarse and fine DMC cutpoints were 1.40 and 1.38 SG, respectively. The tracer cutpoints were 1.42 and 1.39, respectively.

The vessel cutpoint is usually 0.05 SG units higher than the coarse coal DMC cutpoint; and the cutpoint of a vessel is usually close to its feed medium density. Assuming accurate calibration of the vessel K-Ray, this set of conditions would have put the vessel cutpoint at 1.45 SG units. Putting that with the tracer cutpoints for both DMC circuits we would have:

vessel cutpoint	1.45
coarse coal DMC cutpoint	1.42
fine coal DMC cutpoint	1.39

Since these values are substantially different, some potential exists for yield improvement. The amount of the improvement can be estimated by mathematical simulation.

9. CONCLUSIONS

The Plant A DMC circuits were tested using 32 mm density tracers. In the test of the fine coal circuits, 16 mm tracers were also used. Coal and medium samples were recovered immediately after each tracer test. The resulting data and partition curves are presented, together with details of operating conditions and other observations. While some tracers were buried in the coal or refuse beds on the drain- and-rinse screens and were lost, those losses were not sufficient to seriously compromise the results.

Many ancillary observations and measurements were made during the same month for correlation with the observed tracer partitioning performance and for prediction of size-by-size coal partitioning.

Medium circuitry is considered to be good, but it is recommended that the relatively inaccurate balance-beam type Marcy gauge be replaced with a more accurate dial type. Medium density control loops were functioning quite adequately. Loadings on coarse circuit drain-and-rinse screens were variable, and this would contribute to magnetite consumption. DMC life could be extended if more attention were paid to alignment of the components.

Neither circuit exhibited gross misplacement of very low-density particles to refuse or of very high-density particles to product. In both circuits the offsets between feed medium densities and cutpoints were surprisingly low. A contributing factor would have been the Marcy gauge problems.

Feed rate to the coarse coal circuit was estimated to be quite high at 814 tph, compared with a process design figure of 444 tph. Yield was also lower due to the quality of feed coal. Operating pressure was very good. Due to wear there was some variation in apex sizes and this was probably the main reason for the relatively poor Ep.

Feed rate to the fine coal circuit was close to design but, again, yield was lower. No pressure reading was available, but this was only a temporary problem. The feed distributor appears to be poorly configured, but this has not compromised process efficiency. Apex diameters were similar and, in spite of the poor distributor configuration, partitioning was excellent for both 32 mm and 16 mm tracers.

One of the advantages claimed for density tracers is that, unlike conventional sampling and float/sink analyses, partition curves are typically available in less than one hour from commencement of the test. This allows any remedial action to be quickly undertaken to stem any observed loss of product. That advantage was amply demonstrated in the current case where, 12 months after sampling, sample sieving and float/sink work for the seven circuits involved in this project were completed only a few months ago. It must be said, however, that under very detailed instructions, Precision Testing Laboratories have conducted the float/sink work with great care and precision.

Based on the density tracer partition curve and Marcy determinations of the densities of feed, overflow and underflow medium, predictions were made of the forms of partition curves for a number of coal size fractions down to 0.5 mm. When float/sink analyses were finally completed, partition curves derived in the conventional way were compared with the predictions. For the coarse coal circuit and for the coarser fractions in the fine coal circuit the match was near-perfect. Only for the finest fraction in the fine coal circuit was there a significant discrepancy and this may relate to the Marcy gauge problems, to possible degradation of the samples during laboratory processing and to the inaccuracies inherent in float/sink analyses of fine coal.

This generates confidence in the ability of the density tracer technique to provide accurate estimates of DMC performance.

Two actions are recommended to optimize yield:

1) Coarse coal DMC efficiency should be improved by careful matching of apex diameters. The potential yield improvement will be estimated by simulation.

2) Careful matching of the cutpoints of the vessel and the two DMC circuits would also increase yield and will be simulated. To achieve that match would require careful calibration of all three K-Rays using an accurate Marcy gauge, followed by a series of partition curve tests to determine the current offset between medium density and cutpoint for each circuit. That would allow calculation of the appropriate relationship between cutpoints for the three circuits. The partition curve determinations could utilize density tracers or conventional float/sink analyses.

APPENDIX I-B

Detailed Follow-Up Reports
Plant Site B

FINAL PLANT ASSESSMENT REPORT
"DENSE MEDIUM CYCLONE OPTIMIZATION"

REPORT FOR PLANT SITE "B"

Project Period:

December 14, 2000 – December 30, 2004

DOE Project Number:

DE-FC26-01NT41061

Participating Organizations:

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Mining & Minerals Engineering
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P.O. Box 1985
Beckley, West Virginia 25801

Massey Energy Company
315 70th Street
Charleston, West Virginia 25304

1. INTRODUCTION

This study was conducted as part of the project "Dense Medium Cyclone Optimization" funded by the U.S. Department of Energy. Team members are:

- Virginia Polytechnic Institute and State University
- Massey Coal Services
- Partition Enterprises Pty Ltd
- Precision Testing Laboratories

2. THE CIRCUIT AND FEED COAL

The plant incorporates a primary heavy medium circuit treating 50 x 1 mm (-2 inch +14 mesh) raw coal with a feed medium density of around 1.6 SG. The coarser portion of primary floats is retreated in a secondary DMC circuit which operates at low medium density to generate a high value premium product of less than 3% ash. Fines are processed by spirals and flotation. Key aspects are generally as detailed in Flowsheet FS-001 dated June 1996.

In the primary circuit, most of the drain medium is returned to a mixing box (Figure 1) from which it is split between the center and outer sections of a draft-tube DMC feed sump. Interestingly, much of the drain medium from the secondary sinks (or middlings) screen is directed to the primary feed sump outer section. The feed slurry of medium plus coal is pumped past a nucleonic density gauge and up a vertical line into a generally-symmetrical distributor which feeds the two DMCs. Samples of medium can be manually recovered from overflow of the mixing box.

As part of the system for control of medium density, a proportion of medium is bled from the circuit to be concentrated and decontaminated in magnetic separators. That bleed is composed of medium drained from one of the primary floats screens (No. 2). Compared with the average circulating medium its magnetite will be finer and it will carry a larger proportion of fine contaminants per ton of magnetite. This may increase magnetite losses, since magnetic separators are considered to preferentially recover coarser magnetite particles. However, for a circuit which operates at high medium densities, it has the positive effects of keeping the circulating medium relatively coarse and relatively low in contaminants. The above-noted flow of secondary sinks medium into the primary circuit has another desirable effect in that it contributes to the coarseness of magnetite in the primary circuit.

The top decks of the primary floats screens utilize a piano-wire screen system. At the time of these trials the slot widths were approximately ¼ inch, but these panels are frequently changed to meet product requirements. Oversize from the top deck becomes feed to the secondary circuit which incorporates a correct medium sump and wing-tank arrangement. Density control is by water addition to the correct medium pump suction, and the nucleonic density gauge is located downstream of that pump where it can monitor medium without feed coal. Stability of density control is critical to this circuit because of the low medium density and the consequently extreme proportion of "near-gravity" material. Again, a well-arranged and relatively symmetrical distributor is used to split slurry between the two DMCs.

Figure 1.
Viewed from above, the left and right lines direct drained medium from primary floats and primary sinks, respectively, to a mixing box. Mixing is not complete, so the Marcy sample recovered from overflow at one side of the box is of lower density than the average. Between this point and the nucleonic density gauges, further biases are caused by the addition, in the DMC feed sump, of secondary sinks medium and of raw coal.

Flowrates and distributions of spray water on drain-and-rinse screens are generally excellent (Figure 2). This is especially important with the multi-deck screens on primary rejects, primary floats and secondary clean coal. It appears that a large amount of fresh water is used, and the author is not aware if the plant water circuits are fully closed.

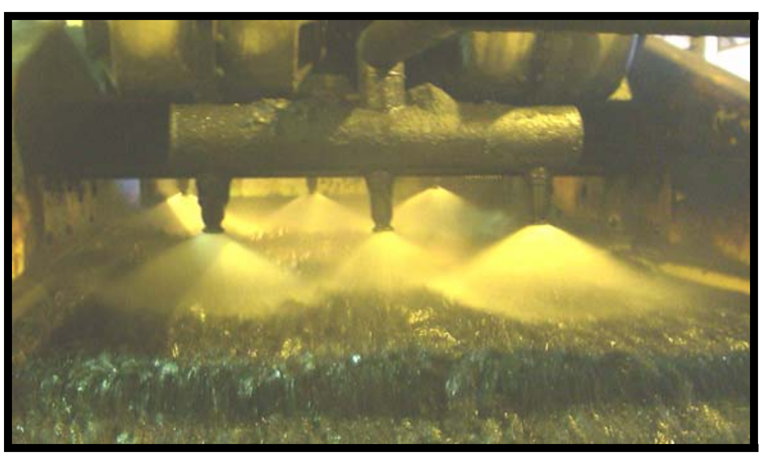


Figure 2.
In the Plant B DMC circuits, a number of screens, including this primary floats screen, have multiple decks. Good sprays with copious water flows limit magnetite losses.

3. DMC DIMENSIONS AND CONDITION

The two primary DMCs are Krebs 33 inch units. Further details are presented in Table 1 and Figures 3 and 4. Most components are ceramic tiled, but the lower cones and spigots are monolithic. The latter appeared to be quite new at the time of these trials. The bodies were in fair condition but had significant wear grooves adjacent to flanges, particularly the flange where the lower cone is fitted. For the DMC furthest from the superintendent's office, the groove was approximately 1 inch deep.

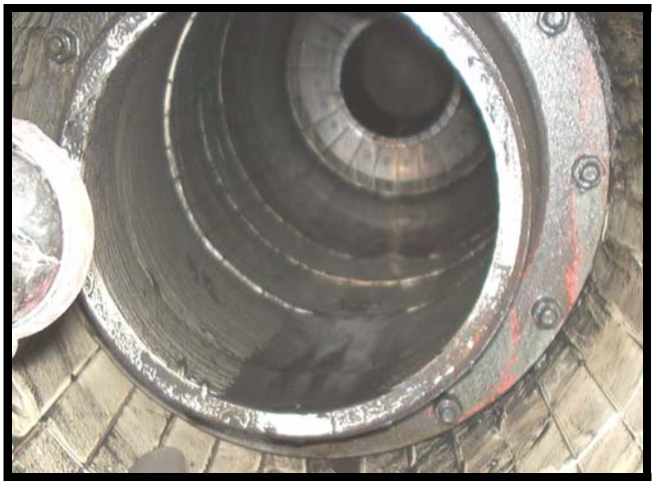


Figure 3.
Internals of a primary DMC, viewed from the spigot end. The components are in fair to very good condition and there are small outward "steps" of no more than 0.2 inches. Seen as bright arcs, they tend to reduce component life but cause little detriment to partitioning efficiency. Less obvious is an inward "step" of 0.2 to 0.3 inches at the spigot flange of both units. Inward "steps" tend to be more detrimental.

The apex ends were measured at 11.57 inches and were very round. The plant superintendent advised that the as-new values are nominally 11.50 inches and the corresponding value for vortex finder IDs is 14.00 inches. The ratio of vortex finder to cyclone diameter matches the original Dutch State Mines (DSM) recommendation. The ratio of apex to vortex finder was 0.83 which is quite large and is considered appropriate for this moderately low-yield coal. The large apex diameter also reduces the degree of medium segregation, which with this relatively coarse medium could lead to yield loss through particle retention and surging. A representative from the cyclone manufacturer (Krebs) has recently advised that the inlet areas are 73 square inches. This is double the area recommended by DSM and gives much higher volumetric capacity. There may be a small reduction in separating efficiency for small particles, but with a nominal bottom size of 1mm this is not considered to be a major drawback.

Figure 4.
Internal view of a secondary DMC. The bright areas at the corners of the photo are the end face of the apex and the outermost grey band is the inside of the apex. Two of the body components have been mis-aligned. One of the arcs shows an outward "step" of 0.4 inches on the left but small inward "step" (no bright arc) on the right. With no significant inward "steps," processing efficiency is not compromised, but component life may be slightly reduced.

The two secondary DMCs are Krebs 26 inch units with nominal vortex finder and apex diameters of 8 and 7 inches, respectively (Table 2). That vortex finder diameter is unusually small for a DMC of that diameter and the ratio of apex to vortex finder diameter was unusually large, even for a relatively low-yield situation.

The small vortex finder would cause a small reduction in capacity and would have an influence on medium stability, which is commonly measured in terms of the density difference between overflow and underflow medium.

That large a ratio of apex to vortex finder diameter may bring a number of advantages and some disadvantages including:

- a reduction in offset between feed medium density and cutpoint which would tend to reduce any cutpoint differences between the two DMCs,
- a slight deterioration of Ep which could impact the yield of fine particles, mitigated by the fact that the feed coal is nominally +5mm,
- a high volumetric split of medium to underflow which reduces the increase of cutpoint with decreasing particle size and can lead to a loss of fine coal, again mitigated by the fact that the feed coal is nominally +5mm, and
- a reduced differential between the densities of underflow and overflow medium, reducing the likelihood of retention of near-density particles and consequent loss of yield by surging.

All DMCs appear to be well installed with reasonably unrestricted discharge of overflow and underflow.

Plant capacity is currently limited by the capacities of the drain-and-rinse screens for the secondary DMC product and middlings. With high-yield coals these become overloaded, reducing screening efficiencies and substantially increasing magnetite consumption. On occasions, plant throughput is reduced by nearly 50 percent to limit the loads on those screens.

4. OPERATING PRESSURES

Throughout the tracer testing and coal sampling periods, primary and secondary gauge pressures were steady at 14.5 and 15.5 psi, respectively. Making due allowance for DMC diameters, medium densities and gauge positions, these readings equate to 6.9 and 12.0 "cyclone diameters," respectively.

The primary pressure of 6.9 "diameters" is below the range of 9 to 12 "diameters" usually recommended by the author. An increase to 10 "diameters" should give a slight yield improvement, while increasing the capacity of the primary DMCs by approximately 20 percent. Operators advise that for high-yield coals at high throughput, a substantial proportion of coal can be lost to primary DMC rejects (a common symptom of floats overload). If, in the future, additional secondary DMC drain-and-rinse capacity is installed, it is likely that primary DMC floats capacity will become the next bottleneck. In discussions with plant personnel, it was indicated that the DMC feed pump could be sped up to increase pressure at the gauge from 14.5 to 17 psi, equivalent to about 8.3 "diameters." If this was done the pump would need to be overhauled more frequently. To raise pressure into the recommended range would probably call for installation of a larger motor and starter and, perhaps, a further electrical upgrade.

The pressure for the secondary cyclones was at the high end of the recommended range. There was some fluctuation of loads on the secondary middlings and secondary product screens. This could arise from slight variations in medium density or from particle retention and surging, which causes losses of clean coal. One way to reduce or limit surging is to reduce inlet pressure. This will be further addressed later in the report.

5. MEDIUM DENSITY MONITORING AND CONTROL

5.1 Primary Circuit

Separation density is, of course, closely related to medium density (usually 0.06 to 0.12 SG units higher, depending on DMC configuration and operating conditions). However, in this circuit medium density cannot be accurately monitored for four inter-related reasons.

- Medium returned from the floats and sinks drain-and-rinse screens is sampled for Marcy density determinations. If drainage is near-complete, that material should closely match the density of the medium fed to the DMCs. However, as part of the scheme for sump level and medium density control, a portion of the floats medium is bled off to join the rinsed medium and be directed to the regeneration circuit. Concentrate from the magnetic separators is returned directly to the outer portion of the DMC feed sump, increasing the density of the circulating medium.

- Secondly, as shown in Figure 1, the floats and sinks drain streams come together only in the mixing/distribution box and are not adequately mixed before the discharge/sampling point. Thus, the Marcy gauge gives a biased reading.
- Thirdly, a significant flow of secondary DMC underflow reports to the primary DMC feed sump, between the sampling point and the nucleonic gauge. Typically its density will not differ greatly from that of the primary medium, but this will fluctuate from time to time. There is also a water addition to the suction side of the DMC feed pump.
- Finally, coal is added to the medium before it passes the nucleonic density gauge. Thus if the average density of the raw coal rises, the density control system will act to reduce the density of the circulating medium.

The Marcy gauge used for primary feed medium was itself mis-calibrated, reading high by 0.02 SG units over the relevant range, showing 1.60 SG for a sample which was actually 1.58 SG. Interestingly, with coal on, the nucleonic gauge was recording a steady 1.58 +/- 0.00. However, for the above-noted reasons, it is likely that the true density of the medium fed to the DMCs was significantly different. Fortunately, the separation occurs at a region of little “near-gravity” material, so the impact on yield of medium density control errors is not great.

5.2 Secondary Circuit

The secondary circuit incorporates a correct medium sump and wing tank. The nucleonic gauge is located on the correct medium line (without coal) and after a water addition point. A representative Marcy sample can be recovered from a head tank. This is a good configuration. However, the Marcy gauge used for that circuit was significantly in error. A calibration procedure gave the following result:

$$True\ Medium\ SG = \frac{0.990\ x\ (Marcy\ Cup\ \mathrm{Re}ading) + 0.051}{1.041}$$

A major contributing factor appeared to be that the flask held approximately 4 percent more than standard volume of 1.00 liter. The flask, and possibly the gauge itself, should be replaced.

The nucleonic gauge was not accurately calibrated, even against the erroneous Marcy gauge. It indicated steady control at 1.33 +/-0.00 SG units, when the true value was approximately 1.265 (to the nearest 0.005).

In this case, the proportion of “near-gravity” material is very high, so yield is very highly dependent on medium density. However, density adjustments are made on the basis of product quality analyses from the laboratory, so there is a tendency to arrive at an appropriate medium density, even if there is a bias in its measurement.

6. DENSITY TRACER TESTS AND RESULTS

The density tracer test was conducted using 32 mm cubic density tracers. Preliminary "sighting" tests had shown the ranges of tracer densities required and demonstrated that there was little likelihood of retention. Operating conditions and results for the primary circuit and secondary circuits are presented in Tables 1 and 2, respectively.

6.1 Primary Circuit

In spite of the low pressure, large inlet and large apex, the differential between overflow and underflow medium densities is a little high at 0.37 SG units. This probably arises principally from the coarse magnetite.

The coal feed rate was estimated at 435 long tons per hour. This is a very high rate for two 33 inch DMCs, but they are fitted with large inlets and the manufacturer puts their combined capacity, when operating with a pressure head of 9 "diameters," at 6,140 gpm (1,394 m^3/h).

Operating at only 6.9 "diameters" of head, volumetric capacity would be 1,221 m^3/h. From the float/sink results, the mean density of raw coal is estimated at 1.7 SG units, so the 435 long tonnes would equate to 260 m^3/h, giving a medium-to-coal ratio in feed of 3.7:1 (vol/vol). This is considered to be just adequate.

The density tracer partition curve shows a cutpoint of 1.75 SG units. That would put the apparent offset between feed medium density and cutpoint at a very high value of 0.17 SG units, but as noted in Section 5, feed medium density could not be accurately determined. Presumably the circuit is able to operate at a high cutpoint without violating product ash targets. The observed cutpoint of 1.75 SG units is close to the upper limit for DMCs operating with magnetite-based (as distinct from ferrosilicon-based) medium.

The Ep was found to be 0.012 SG units. A well-tuned circuit should be capable of partitioning these tracers with an Ep of around half that value, but the curve shows no gross misplacement, and at that separating density the potential yield improvement from an improved Ep would be very small.

In summary, the primary DMCs were effecting a good separation, but appear to be operating close to their maximum capacity at the observed operating pressure. Additional capacity could be realized by operating at higher pressure, but some aspects of the setup and medium characteristics are unusual and have potential to cause yield losses.

6.2 Secondary Circuit

By timing the collection of analysis samples, the coal feed rate to this circuit was estimated at only 86 long t/h (db) which is a very low rate for two 26 inch DMCs. Yield was estimated at 72% (db).

Operating pressure was at the high end of the recommended range. The densities of feed, overflow and underflow medium suggest a volumetric split of approximately 81 percent to overflow. This is inconsistent with the author's experience of the relationship between slurry split and the ratio of apex diameter to vortex finder diameter. The inconsistency may relate to the unusually small diameters of both orifices.

The differential of 0.32 SG units between overflow and underflow medium densities is a little high for these circumstances and may be attributed to the high inlet pressure and the unusually small sizes of both vortex finder and apex. Large differential signals a danger of particle retention leading to surging and loss of yield. In fact, there may have been mild surging during the test period. Loads on both the secondary clean coal and middlings screens appeared to fluctuate a little, as did the underflow medium density, and the partition curve has indications of a low-density "tail" which directs about 4 percent of even the cleanest coal particles to middlings. Unfortunately, definition of the curve was sub-optimal because the original plan was to focus on high-cutpoint plants, so the stock of density tracers encompassed only two densities below 1.40 SG.

Another factor that can contribute to surging is unusually low levels of ultrafine clay contamination in the circulating medium. Raw coal at Plant B appears to carry relatively little clay, and only a small portion of that would pass through the primary DMCs and report to the secondary circuit.

The fact that the cutpoint was comfortably higher than the feed medium density suggests that any surging was not severe, and the apparent Ep value is considered reasonable for a two-unit module. However, particle retention and surging can be exacerbated or eliminated by small changes in operating conditions. Some means of reducing the likelihood of surging will be discussed in Section 9.

Table 1

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

Green Valley Primary HMC Circuit - June 2001

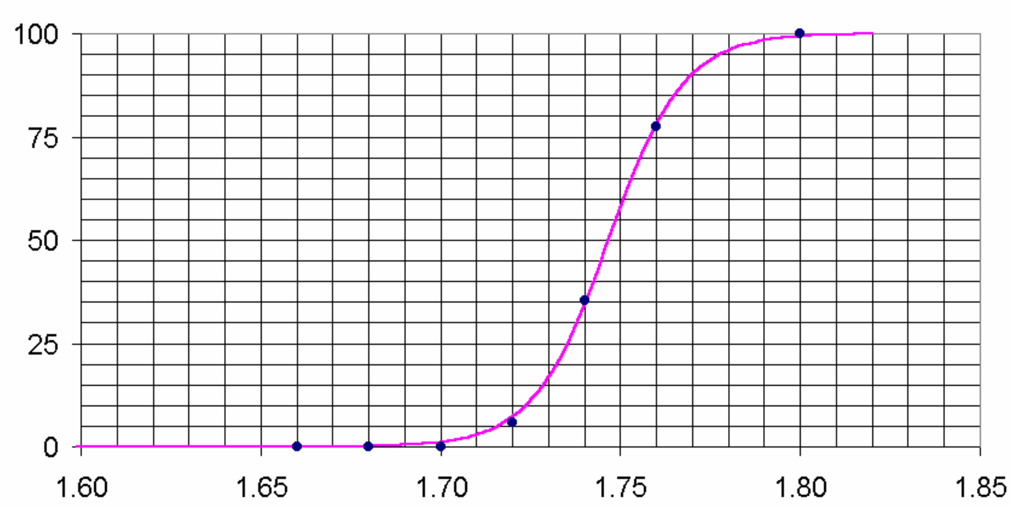
Test ID	Module ID	Date	Time
Green Valley Primary	DMCs	June 13, 2001	19:22 to 20:18
Feed Type	Plant Feed lt/h	Circ Feed lt/h	Tracer Size
Sewell	595 (ar)	435 (db)	32mm
Diameters of (inches)	Body	Vortex Finder	Apex
Unit 1	33	14	11.57
Unit 2	33	14	11.57
Condition of	Body	Vortex Finder	Apex
Unit 1	fair	good	v good
Unit 2	fair	good	v good
Apex Alignment	Inlet Pressure	Gauge Posn	Head
good	14.5 psi	25 in below inlet	6.9 diameters
Magnetite	Feed RD	Overflow RD	Underflow RD
	1.58 (see below)	CC1 1.43 CC2 1.46	1.81

Other Operating Conditions / Observations

Medium from the sample point is not representative of medium fed to the HMCs, and the nucleonic gauge monitors medium plus coal. These factors affect the apparent offset. The Marcy gauge used for primary feed medium was reading high by 0.02RD units. Overflow and underflow RDs measured using Marcy assigned for secondary HMCs (Table 2). It was also in error, but the above readings have been corrected. Refer text for details on HMC condition. Inlet head is below the recommended 9 to 12 "diameters".

R D	Number of Tracers . . .							**% to**
	in	retrieved from...					Recovered	**U/flow**
	Feed	Overflow			Underflow			
		unit	unit	Total	unit	Total	b+c	
	a	1	2	b	1	c	d	
1.50	40	22	16	38	0	0	38	0
1.66	40	16	16	32	0	0	32	0
1.68	40	22	9	31	0	0	31	0
1.70	40	14	14	28	0	0	28	0
1.72	40	19	13	32	2	2	34	6
1.74	40	13	9	22	12	12	34	35
1.76	40	6	1	7	24	24	31	77
1.78	40	0	1	1	27	27	28	96
1.80	40	0	0	0	31	31	31	100

Density Tracer Partition Curve



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30:**	**nil**	**Cutpoint:**	**1.75**	**Ep:**	**0.012**

Table 2

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

Green Valley Secondary HMC Circuit - June 2001

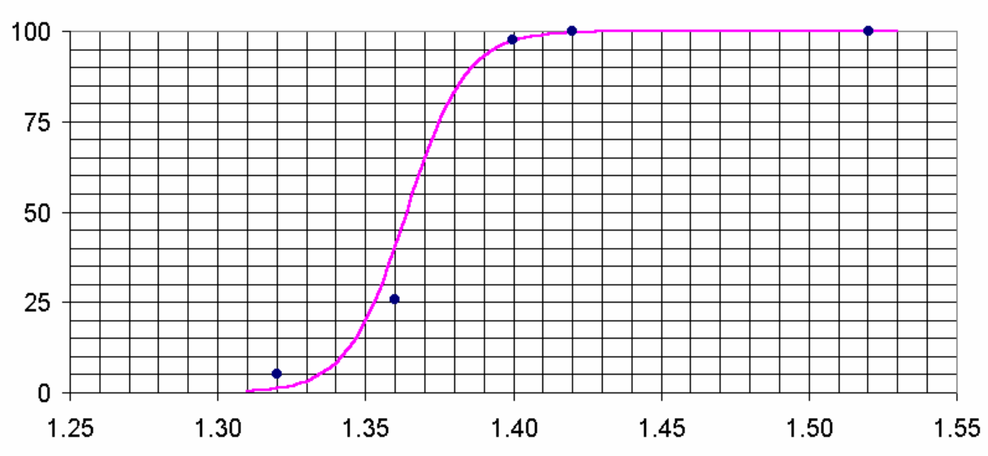
Test ID	Module ID	Date	Time
Green Valley Secondary	DMCs	June 13, 2001	20:40 to 20:55
Feed Type	Plant Feed lt/h	Circ Feed tph	Tracer Size
Sewell	595 (ar)	85.5 (db)	32 mm
Diameters of (inches)	Body	Vortex Finder	Apex
Unit 1	26	8	7.03
Unit 2	26	8	7.03
Condition of	Body	Vortex Finder	Apex
Unit 1	good	good	v good
Unit 2	good	good	v good
Apex Alignment	Inlet Pressure	Gauge Posn	Head
good	15.5 psi	28 in below inlet	12.0 diameters
Magnetite	Feed RD	Overflow RD	Underflow RD
	1.26	1.20	1.52

Other Operating Conditions / Observations

Volume of Marcy flask is wrong (see text) but RDs have been corrected. Nucleonic gauge reads high by 0.05 RD units. Some outward "steps" in HMC internals (not critical, see text). Fluctuating loads on screens may suggest minor surging and loss of yield. Would probably be reduced at lower pressure. Yield estimate 72% (db) by timing of coal analysis samples. Early plans did not include testing at Green Valley, so few tracers were available at low densities. Consequently the curve is not fully defined, but suggests a low-density "tail" consistent with surging.

R D	Number of Tracers . . . in Feed	retrieved from... Overflow unit	Overflow Total	Underflow unit	Underflow Total	Recovered b+c	**% to U/flow**
	a	1	b	1	c	d	
1.32	40	36	36	2	2	38	5
1.36	40	29	29	10	10	39	26
1.40	40	1	1	39	39	40	98
1.42	40	0	0	40	40	40	100
1.52	40	0	0	39	39	39	100

Density Tracer Partition Curve



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30: 1%**	**Cutpoint: 1.36**	**Ep: 0.011**

8. SIZE-BY-SIZE PERFORMANCE

8.1 Predicted from Density Tracer Results and Medium Behavior

8.1.1 General

The partitioning behavior of coal particles larger than about 8mm may be expected to approximate that of the 32mm tracers. To predict the partition curves for smaller particles we will utilize the observation that there is a strong tendency for all the curves to pass through or close to a “pivot point” which occurs at a partition number tending to match the volumetric fraction of medium which reports to DMC underflow.

There is a strong phenomenological basis for this behavior which arises from the following points which relate to a DMC operating with a truly stable medium:

- There is no tendency for particles of density equal to the medium density to report preferentially to overflow or to underflow. Thus they are partitioned according to the volumetric split of medium.
- Due to fluid drag phenomena, very small particles (of any density) are also partitioned according to the volumetric split of medium.
- For particles of a density not equal to the medium density, the partition number for a small particle will be closer to the medium split than that for a large particle. This also relates to fluid drag and explains why Ep values increase with decreasing particle size.

Of course, particulate medium such as slurries of magnetite in water are never truly stable, and the author usually estimates the volumetric split of medium by measuring the densities of feed, overflow and underflow medium and invoking the formula:

$$Volume\ \%\ to\ Underflow = 100\frac{Feed\ \ Medium\ SG - Overflow\ Medium\ SG}{Underflow\ Medium\ SG - Overflow\ Medium\ SG}$$

This may be applied to the secondary circuit at Plant B:

$$Volume\ \%\ to\ Underflow = 100\frac{1.26-1.52}{1.20-1.52} = 81\%$$

It could not be applied to the primary circuit because the density of feed medium could not be reliably determined. As a fallback, the internal dimensions were used to estimate that the medium split (and pivot partition number) may have been around 80% to overflow.

8.1.2 Primary Circuit

An DMC performance model developed by the author (Wood, 1991) suggests that, except at exceptionally low pressures or exceptionally high medium viscosity, a single DMC can achieve the rather small size-by-size Ep values listed in Table 3. These are downgraded as follows:

- increased by 50% for factors including the internal roughness of the DMCs,
- increased by a further 20% because of the low operating pressure,
- increased by 0.005 because two separators are used (albeit they are well-matched),
- increased by 0.005 due to the limitations of float/sink analyses.

This gives the cutpoints and Ep values listed in Table 3 and illustrated in Figure 5. Cutpoint for the coarse fraction is assumed to be similar to that for 32mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 20% to underflow.

8.1.3 Secondary Circuit

The secondary circuit was operating at a pressure of 12 “diameters” which is the upper limit of the author’s preferred range. Accordingly, in this case there is no downgrade of predicted Ep values on the basis of pressure and only the following factors are applied:

- increased by 50% for “real-world” situations,
- increased by 0.005 because two separators are used (albeit they are well-matched),
- increased by 0.005 due to the limitations of float/sink analyses.

This gives the cutpoints and Ep values listed in Table 4 and illustrated in Figure 6. Cutpoint for the coarse fraction is assumed to be similar to that for 32mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 21% to underflow.

8.2 Comparison of Predicted Partition Curves with Float/Sink Results

In conjunction with the tracer tests, coal samples were also recovered and their analyses have recently been completed. Those data have been used to generate partitioning results for some size fractions of coal. Derived parameters (cutpoint and Ep) are included in the above tables. They are not highly reliable for reasons which relate to drain-and-rinse screen apertures and which are outlined in the tables. The float/sink results suggest that predicted cutpoints are approximately 0.02 SG units high. This is a common finding for these relatively coarse particles and is considered to relate to the absorption and desorption by coal of water and of float/sink liquids.

The limited float/sink data indicate Ep levels which are consistent with the predicted values.

Table 3.
Primary DMC
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model SG units	Predicted for Plant B Primaries from tracer test (allowing for two well-matched DMCs) SG units		Observed for Plant B based on float/sink (see Section 8) SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.003	1.75	0.014	1.73 *	0.015 *
-4 +2	2.8	0.013	1.77	0.034		
-1+0.5	0.7	0.052	1.87	0.104		

* Because of the deck and aperture configurations of the drain-and-rinse screens, it was not feasible to obtain samples for accurate definition by float/sink of partition curves for particles smaller than 8mm. Even the case of +8 mm particles, reliable samples could not be recovered from the refuse screen, so their partition points are based on samples from feed and floats only. This removes any possibility for useful material balancing to account for sampling and analysis errors and for particle degradation. Accordingly, the “observed” partition points do not form a smooth curve (Figure 5) and are not constrained to lie in the range 0 to 100%. They appear to show a cutpoint about 0.03 SG units lower than that predicted from tracer tests for coarse coal.

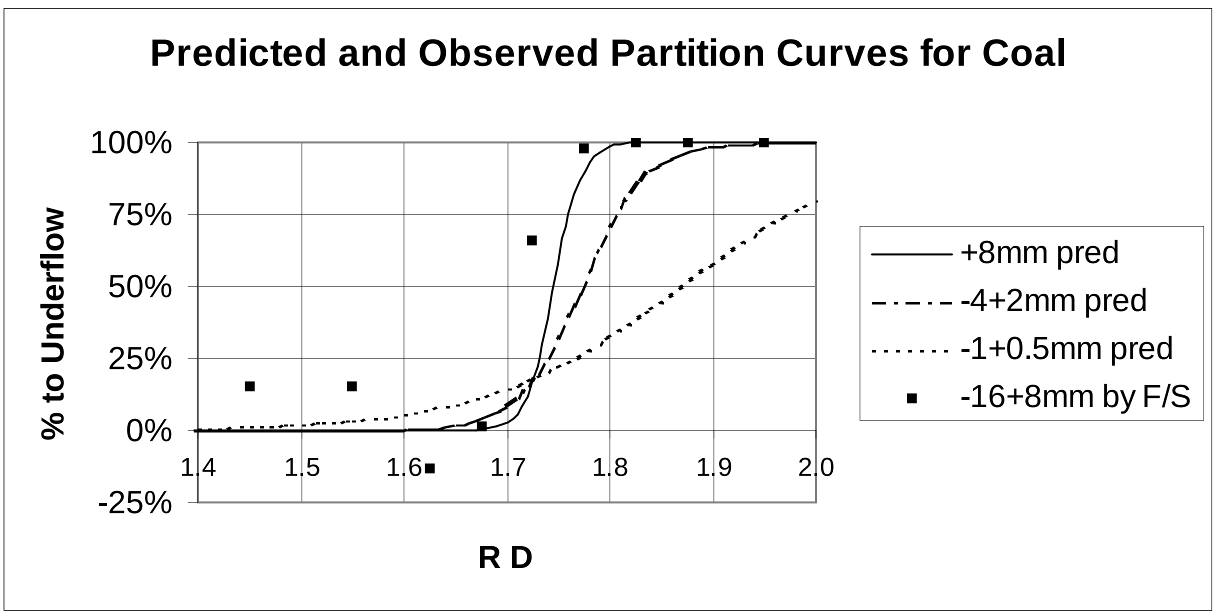


Figure 5.
Observed partition points show moderate agreement with predicted curves for +8mm coal based on density tracer tests. One float/sink point shows “-13% to underflow” - please refer to the notes in Table 3.

Table 4.
Secondary DMC
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model SG units	Predicted for Plant B Secondaries from tracer test (allowing for two well-matched DMCs) SG units		Observed for Plant B based on float/sink (see Section 8) SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.003	1.36	0.015	1.36 *	0.02 *
-8 +4	2.8	0.007	1.36	0.020	1.36 *	0.02 *

* Because of the deck and aperture configurations of the drain-and-rinse screens, it was not feasible to obtain samples for accurate definition by float/sink of partition curves for particles smaller than 4mm. Even in the case of +8mm particles, reliable samples could not be recovered from the clean coal screen, so their partition points are based on samples from feed and middlings only. This removes any possibility for useful material balancing to account for sampling and analysis errors and for particle degradation. Accordingly, the "observed" partition points do not form a smooth curve (Figure 6) and are not constrained to lie in the range 0 to 100%. The predicted curves below appear to be shifted about 0.02 units higher than the "observed" results, which are themselves subject to significant error.

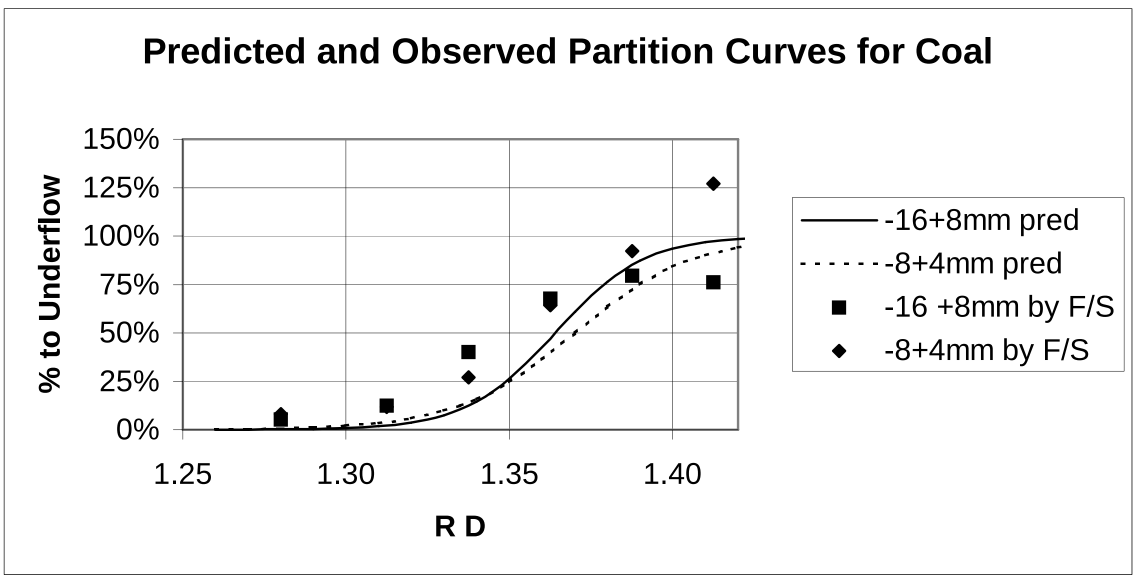


Figure 6.
Observed partition points show moderate agreement with predicted curves for –16+8mm and –8+4mm coal based on density tracer tests. One float/sink point shows "127% to underflow" - please refer to the notes in Table 4.

9. POTENTIAL FOR YIELD IMPROVEMENT

The Plant B plant does not incorporate dense medium vessels or jigs, so there is no requirement to match incremental ash levels from the DMC circuits with incremental ash levels from coarse coal separators which may contribute to a combined product. The primary and secondary circuits will be considered in reverse order.

9.1 Secondary DMC Circuit

For the secondary circuit, medium density is simply driven up or down in order to maintain a cutpoint which generates the required quality of the premium product. This is achieved by feed-back control based on sample analyses and with operator intervention. The fact that the nucleonic density gauge was poorly calibrated does not seriously affect the end result (yield at a specified product quality). It does, however, provide misleading signals which would limit the ability of operators to appreciate the process and develop the confidence to deal with unusual situations. The problem is a simple one and has, hopefully, already been corrected by plant personnel. Loadings on the secondary clean coal and middlings screens were also observed to fluctuate somewhat. This is sometimes associated with particle retention and consequent surging loss of coal to tailings. There was little supporting evidence for surging. It may simply have been that this very sensitive separation was being affected by very minor fluctuations in the density of feed medium.

The overall Ep value for tracers (0.011 SG units) is reasonably good, but any actions to maintain or improve that value will be well rewarded in terms of yield of this high-value product. Key issues are:

- maintaining dimensional similarity of the cyclones, especially of apex diameter,
- maintaining inlet pressure around 12 “diameters,” and
- tuning of the level and density control loops with an emphasis on tight short-term control of medium density.

The reasoning behind the selection of small vortex finder and apex sizes is not known. It may have been seen as a means to sharper separation, but since there are few fine particles in the feed this should not be a serious issue. The use of larger orifices would increase capacity and they could be selected to reduce the volumetric split to overflow. This would:

- allow the use of a slightly higher feed medium density,
- reduce the differential between underflow and overflow medium density, and
- reduce any potential for yield loss through surging.

9.2 Primary DMC Circuit

The primary DMCs were shown to perform a very adequate job of rejecting stone. They were operating with reasonable partitioning efficiency at a high cutpoint, so the potential for increasing yield of secondary middlings or of the –1/4 inch product is limited.

Some aspects of the circuit configuration make it impractical to accurately monitor the density of circulating medium, but some of those aspects are based on sound reasoning such as a desire to maximize magnetite coarseness in the primary DMC circuit while maximizing magnetite fineness in the secondary circuit. It is suggested that the primary floats and sinks drain lines be combined earlier to ensure good mixing of the medium at the Marcy sampling point. Even then it would not reflect the influences of:

- extraction of bleed medium,
- return of overdense medium,
- addition of middlings screen underflow,
- addition of water, and
- inclusion of raw coal.

To avoid these problems while retaining the desirable interconnection of the primary and secondary circuits would require some circuit redesign. Perhaps all the current medium input streams and the water addition could be combined in a mixing box ahead of the existing medium distribution box. A second line from the mixing box could pass a K-Ray located on a U-tube before re-joining the main flow into the existing distribution box. A drawback would be increased response time to changes in medium density cutpoint, but this should not be a problem for this high density separation.

Alternatively, the inability to reliably measure medium density can be accepted and density tracer tests could be conducted on a regular basis as a check that partitioning efficiency is being maintained and to monitor the amount by which the cutpoint exceeds the K-Ray reading.

Tests in five other coal circuits evaluated in this project have shown that, in cases where sampling access allows accurate determination of partition curves, results of density tracer tests can be used to reliably estimate coal partitioning performance. This should provide confidence in the application of density tracers in the Plant B DMC circuits.

10. CONCLUSIONS

The Plant B Primary and Secondary DMC circuits were tested using 32 mm density tracers. Coal and medium samples were also recovered. The resulting data and partition curves are presented, together with details of operating conditions and other observations. While some tracers were buried in the refuse bed on the primary rejects screen and were lost, those losses were not sufficient to compromise the results.

Many ancillary observations and measurements were made for correlation with the observed tracer partitioning performance and for prediction of size-by-size coal partitioning. The Plant B screen configurations make it impractical to derive accurate partition curves by the conventional techniques of coal sampling and float/sink analysis. These techniques were applied but the resulting curves were of limited value. The best that can be said is that, so far as they went, they showed moderate agreement with size-by-size partition curve predictions based on density tracer tests. Those predictions are considered to be of useful accuracy, as was demonstrated in comparable tests of five other plant circuits evaluated in this project which were more amenable to reliable sampling.

Circuit observations at Plant B included inspection of the DMC internals. The bodies were in fair condition and the key components, the vortex finders and apexes, were in good condition, a prerequisite for efficient partitioning.

One of the advantages claimed for density tracers is that, unlike conventional sampling and float/sink analyses, partition curves are typically available in less than one hour from commencement of the test. This allows any remedial action to be quickly undertaken to stem any observed loss of product. That advantage was amply demonstrated in the current case where, 11 months after sampling, sample sieving and float/sink work for the seven circuits involved in this project have only recently been completed. It must be said, however, that under very detailed instructions, Precision Testing Laboratories have conducted the float/sink work with great care and precision.

Primary DMC Circuit

Operating pressure in the primary circuit was only 6.9 “cyclone diameters of head.” The report discusses the modifications which would be required to increase it to the recommended range of 9 to 12 “diameters.” At low-to-moderate feed rates this should slightly improve partitioning efficiency, but because of the high primary cutpoint it will have little impact on yield. However, discussions with plant personnel suggest that the primary DMCs have the potential to limit plant capacity when treating high-yield coal. By running at higher pressure that potential bottleneck could be avoided, but performance should be monitored to avoid surging which may arise with the combination of correct pressure but coarse magnetite.

Partitioning of density tracers was moderately efficient and the apparent offset between K-Ray reading and cutpoint was very high at 0.17 SG units. However, for reasons detailed in the text, the K-Ray reading is not representative of the true density of medium fed to the DMCs. This relates to the presence of raw coal in the material passing the K-Ray, inadequate mixing and sampling of medium, and to interconnections between the primary and secondary circuits, designed to separately control the character of medium in those circuits. Possible modifications are suggested to allow accurate monitoring of medium density. Alternatively, a partial modification could be undertaken and circuit performance could be periodically determined using density tracers.

Secondary DMC Circuit

These critical units were in good condition and the operating pressure was at the high end of the desirable range. Monitoring of medium density showed significant error due to a combination of an oversized Marcy flask and poor calibration of the nucleonic density gauge against the Marcy flask. The impact on yield is not great because the medium density is raised or lowered to the point where the product ash target for the secondary circuit is met.

Because Plant B was not included in the original list of circuits to be tested, the numbers of tracers available at low SGs were not sufficient to completely define the partition curve. Partitioning was reasonably efficient, but there was a suggestion of minor particle retention and minor loss of yield through surging. Coal misplaced in that way is not lost but serves to "sweeten" the lower-value middlings product.

Vortex finders and apexes were found to be unusually small. The fitting of more conventional orifices should serve to increase capacity and could be managed to reduce any risk of surging.

The factor which currently limits plant throughput is the capacity of the small drain-and-rinse screens to recover magnetite from the secondary DMC product and middlings.

APPENDIX I-C

Detailed Follow-Up Reports
Plant Site C

FINAL PLANT ASSESSMENT REPORT
"DENSE MEDIUM CYCLONE OPTIMIZATION"

REPORT FOR PLANT SITE "C"

Project Period:

December 14, 2000 – December 30, 2004

DOE Project Number:

DE-FC26-01NT41061

Participating Organizations:

Virginia Tech
Mining & Minerals Engineering
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Beckley, West Virginia 25801

Massey Energy Company
315 70th Street
Charleston, West Virginia 25304

1. INTRODUCTION AND OBJECTIVES

This study was conducted as part of the project "Dense Medium Cyclone Optimization" funded by the U.S. Department of Energy. Team members are:

- Virginia Polytechnic Institute and State University
- Massey Coal Services
- Partition Enterprises Pty Ltd
- Precision Testing Laboratories

Objectives were:

- to determine whether useful performance data and performance estimates for all sizes can be quickly generated using density tracers supported by other on-the-spot observations including Marcy measurements of the densities of feed, overflow and underflow medium,
- to compare such estimates with the results of conventional float/sink analyses which are much more time-consuming and expensive, and
- to use the tracer results to identify any inefficiencies and develop recommendations for corrective actions.

If the density tracer technique with its rapid results and low cost is demonstrated to be useful in maximizing and maintaining yields, it could become a valuable adjunct to, or partial replacement of, conventional float-sink testing.

2. THE CIRCUIT AND FEED COAL

As well as a heavy medium vessel and spirals, the Plant C plant incorporates a module of six heavy medium cyclones to treat coal in the nominal size range ½ inch x 1mm. Key aspects are generally as detailed in the process flowsheet (Drawing No FS-001 Rev 2), though there are some discrepancies (see below).

Each DMC feeds an individual clean coal screen. The three units fed from one leg of the first feed distributor contribute to a common refuse screen, with oversize directed to a second refuse screen. Underflow from the other group of three DMCs feeds a similar pair of refuse screens arranged in series.

Retrieval of tracers from the drain-and-rinse screens was relatively easy, but launder configurations limited access for sampling. While the density tracer tests encompassed all six DMCs, coal sampling effort was concentrated on the group of three units which offered the better access. It was not feasible to accurately sample DMC feed but the analyses of floats and sinks samples indicate that the feed contained:

- a significant proportion (about 11 percent) of +1/2 inc material, and
- around 6 percent finer than 1 mm.

The latter suggests only moderately effective desliming. It should be remembered that there will have been some breakage in the DMC circuit, offset by some loss of fines through the drain-and-rinse screens.

According to the flowsheet, the DMCs process approximately 43% of plant feed (510 t/h of 1,200 t/h). (The flowsheet does not indicate the moisture basis for these figures). The timed samples of floats and sinks recovered in this study gave a surprisingly similar figure of 42 percent [568 t/h (db) of 1,500 t/h (ar), with an assumed feed coal moisture of 6 percent].

Raw coal and medium are combined in a draft tube sump and pumped to a “Y” splitter which is well positioned at the top of a long vertical pipe run. One leg from the Y-piece is fitted with a nucleonic density gauge, after which an asymmetrical distributor splits its contents between three DMCs. Part of the slurry fed to one DMC can be drawn off via a sample point for determination of its density in a Marcy gauge. The other leg from the Y-piece is similarly configured, but without a nucleonic density gauge.

As in Plant E, when the plant is in operation there is no provision for sampling or monitoring the density of feed medium independent of coal. Medium circuitry is rather complex.

The current plant configuration differs from that presented in Drawing FS1 in at least the following regards:

- Discharge from the DMC pump passes through a system of three distributors (not one).
- The nucleonic density gauge is not located on a medium-only U-tube located under a splitter box. Rather, it monitors medium plus coal in one leg of the first (2-way) splitter.
- Spiral feed overflow is directed to the top deck of a deslime screen.
- Water addition to the DMC circuit appears to be to the pump suction, not to the DMC sump.
- Medium bleed is not taken from a splitter handling combined drainage from clean coal and refuse streams. Rather, there appeared to be a manually controlled bleed of drain medium from clean coal plus an automatically controlled split of drain medium from refuse.
- The deslime screens are not fitted with water sprays, which accounts for the incomplete desliming.
- The flowsheet indicates a coal topsize of ½ inch. On the day of the trials, particles up to 5 inches were observed on the DMC drain-and-rinse screens. Fortunately, the DMC inlets are very large and are not, apparently, prone to blockage.

Figure 1.
Internals of one of the DMCs, viewed from the apex end. Three of the six were inspected, and all components were in a good state of repair. Components had been assembled with imperfect alignment, creating small inward “steps” up to about 1/8 inch and outward “steps” of up to 3/8 inch – particularly at the joint between the lower cone and apex. In this view, outward steps appear as bright arcs. Minor misalignments cause premature wear and cause a slight deterioration in partitioning performance.

Figure 2.
The DMC apexes appeared to be new.

Figure 3.
The apex shrouds appear to be restrictive and may limit the flow of slurry to underflow, thereby increasing the cutpoint.

3. DMC DIMENSIONS AND CONDITION

The six DMCs are Krebs 26 inch units. On the day of the plant trials there was an unplanned shutdown which provided a narrow window of opportunity to inspect the internals of the DMCs. A chain block was rigged to allow removal of the apex shrouds. This was a time-consuming exercise, and the author was able to inspect only three of the six cyclones. However, all were said to be in a similar state of good repair and the observations, which are summarized in Table 1, supported that view.

Each unit is comprised of five monolithic ceramic components plus a apex. Figures 1 and 2 show the internals and apex of one cyclone. Descriptive details are included in the captions. Figure 3 shows one of the units in operation. The underflow shrouds appear somewhat restrictive.

A representative from the cyclone manufacturer (Krebs) advised that, for these units, the:

- “as new” inlet area is 45 sq in,
- vortex finder IDs may be 8 inches or 10 inches (scaling from Figure 1 indicates that they are 10 inches), and
- an additional cylinder section may have been fitted to each unit.

His observations suggest that the units operate at an inlet pressure head of 11.7 “cyclone diameters.” With 10” vortex finders, this set of conditions that should equate to 1655 gpm.

In the three units inspected by the author, the apexes were relatively new with an ID of 7.6 inches. This implies that the ratio of apex ID to vortex finder ID was 7.6/10.0 = 0.76. Compared to many operations this is a bit small, but would be suited to a high-yield situation, so long as particle retention and consequent surging can be avoided.

4. OPERATING PRESSURE

DMC operating pressure is measured by a local dial gauge (these are generally less reliable than micro-processor-based transducers). At the time of the trial the reading was 10 psi. As noted in the next section, feed medium density was difficult to determine, but was probably around 1.5 SG units. Allowing for the gauge position, the estimated inlet head, as defined by Dutch State Mines personnel in the 1940s, was 8.3 "cyclone diameters." This is outside the range of 9 to 11 "diameters" usually recommended by the author. As noted in the summary, the pump has been sped up to increase the pressure to within the desired range. There are also plans to replace the dial gauge with a pressure transducer.

Low pressure reduces the medium-to-coal ratio and DMC capacity. During operation, crowding in the overflow of an DMC can sometimes be observed simply by plunging one's hand into the overflow stream as it discharges from the cyclone. However, such an observation could not be attempted at Plant C due to access restrictions.

In spite of the asymmetrically-arranged three-way distributors there was little evidence on the clean coal screens of severe differences in loading. Timed sampling of oversize from three of those screens also suggested reasonably similar loadings. A contributing factor would be the low inlet pressure.

5. MEDIUM DENSITY MONITORING AND CONTROL

5.1 Monitoring

In the Plant C plant configuration (as at Plant E), when the feed is on, the slurry passing the nucleonic density gauge and the slurry sampled for check and calibration measurements by Marcy gauge both contain raw coal. Thus the density of the medium without coal cannot be readily determined during washing (In most heavy medium plants it can be determined). Nucleonic gauge output is monitored by the process control computer.

When operating without coal feed at Plant C a calibration may be effected, but it is rendered invalid the moment coal feed is introduced. An operator advised that when the coal feed is started the nucleonic gauge signals a brief density increase of approximately 0.06 SG units. As the density control system manipulates medium streams, the slurry density tends back to the cutpoint, but the effect on medium density is probably to reduce it by more than 0.06 SG units. The magnitude of that medium density error is highly dependent on feed rate and on the mean density of the raw coal.

Quite apart from the above considerations, the density of a sample including coal cannot be reliably determined by Marcy scale because of the interfering and biasing effects of the coal which rapidly floats to the top of the slurry in the flask.

It is strongly recommended that means be sought to monitor and sample circulating medium, free of coal. A hand-held test sieve-bend was fabricated and successfully tested at this plant site (Figure 4).

Figure 4.
A hand-held sieve removes coal from sample streams for Marcy determinations of feed medium density. A permanent installation should be considered.

A very low cost temporary fix may be to install a simple in-line screen in the pipe system which delivers medium samples for the Marcy gauge. That would allow a relatively coal-free sample to be obtained while the feed was on, and the nucleonic gauge, although it actually "sees" medium plus coal, could be calibrated against that medium density. It would be better than the current arrangement, but the calibration would wander with every variation in pump rate, plant feed rate, plant feed size distribution and plant feed quality.

The plant Marcy gauge was found to be reading high by about 0.025 SG units. This is of somewhat academic interest since reliable coal-free samples of feed medium could not be recovered. However, the gauge was used to determine the densities of DMC overflow and underflow medium (sampled from underflow of the clean coal and refuse sieve bends, respectively).

5.2 Control

As detailed above, the current circuit configuration at Plant C makes it impossible to accurately monitor medium density. By definition it cannot, therefore, be accurately controlled. Around the time of this trial the plant was suffering many disruptions, but in periods without severe disturbances medium density appeared to fluctuate by about +/-0.01 SG units (5 minute averages). This suggests only moderately effective control, but given the low proportion of “near-gravity” material the impact of those fluctuations on long-term yield would be small.

6. OTHER OBSERVATIONS

6.1 Spillage

Plant C is rather old and of rather complex design with a number of small-capacity process units (including drain-and rinse screens) operating in parallel. This limits plant availability, and it appears that maintenance has presented some problems. Consequently, there were many sources of spillage which detract from the work environment and make access to many items and locations difficult, hazardous or unpleasant. Spillage also induces corrosion and premature failure of processing equipment and of structural steel.

6.2 Magnetite Consumption

Rinse water on the drain-and-rinse screens was poorly applied and many spray apexes were blocked so that, on average, only about half of the screen loads were rinsed. This fits with the comment of an operator that magnetite consumption had recently increased approximately three-fold to more than 3 kg per ton of plant feed.

Another contributor to high magnetite consumption would be poor maintenance of magnetic separators. Some were observed to operate with very low tub levels or with blocked outlets. Some of these issues have been remedied and two new magnetic separators have been installed.

7. DENSITY TRACER TESTS AND RESULTS

After preliminary tests using small numbers of tracers, the main test was conducted on June 18, 2001. Key results are presented in Table 1. Because of the plant layout it was necessary to test all six DMCs as a single separator with a single partition curve. Assessment of the numbers and densities of tracers reporting to each screen usually allows inferences to be drawn concerning performance differences between individual separators. In this case such assessment is hindered by the degree of retention.

After the addition of all the selected tracers it was noted that a considerable number were retained in the DMCs. Consequently, coal feed to the plant was stopped and the DMC feed pump was briefly stopped, causing most of the retained tracers to discharge. Before stopping the pumps, personnel were assigned to each of the drain-and-rinse screens, but two people misunderstood their tasks with the result that tracers which reported to two of the clean coal screens were not retrieved. The ones which were retrieved are listed in Table 2. This made it clear that:

- retention was evident in at least four of the cyclones and, quite possibly in all six,
- the range of retention was not great (about 1.47 to 1.51 SG units).

One point worthy of note is that, for densities above the retention zone, the curve does not rise very rapidly to the limit of “100% to underflow.” This may be an effect of high loading, with the rush of floats to the vortex finder carrying along some higher density particles.

There appears to be some feed bias, possibly arising from one of the asymmetrical three-way DMC feed distributors. Let us assume that all F1.45 tracers report to clean coal and that any such tracers which were not retrieved simply evaded capture from the relevant D&R screen. From Table 1, only five such tracers were recovered from Screen F, while the corresponding figures for the other five screens averaged 18. Partitioning appears not to have been seriously compromised, probably thanks to the fact that the cutpoint is high enough that the proportion of “near-gravity” material is not high. It should also be recalled that the tracers were larger than the feed coal and would therefore accentuate any feed bias.

Also, the presence of retention (hang-up) is not, in this case, a serious problem. The tracers are 32 mm cubes, much larger than the nominal coal top size of ½ inch. Since retention is highly dependent on particle size it is unlikely that the majority of coal particles will be affected, and the percentage of grossly oversize particles (Section 2) is small.

The densities of overflow and underflow medium, unlike feed medium, could be reliably determined and the results are included in Table 1. The differential of approximately 0.32 SG units is considered appropriate.

The broad finding for this particular circuit is that there was no serious misplacement of Floats 1.45 to refuse or of Sinks 1.60 to product, but that the cutpoint cannot be accurately controlled because the feed medium density cannot be reliably monitored.

Table 1

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

Liberty, June 2001

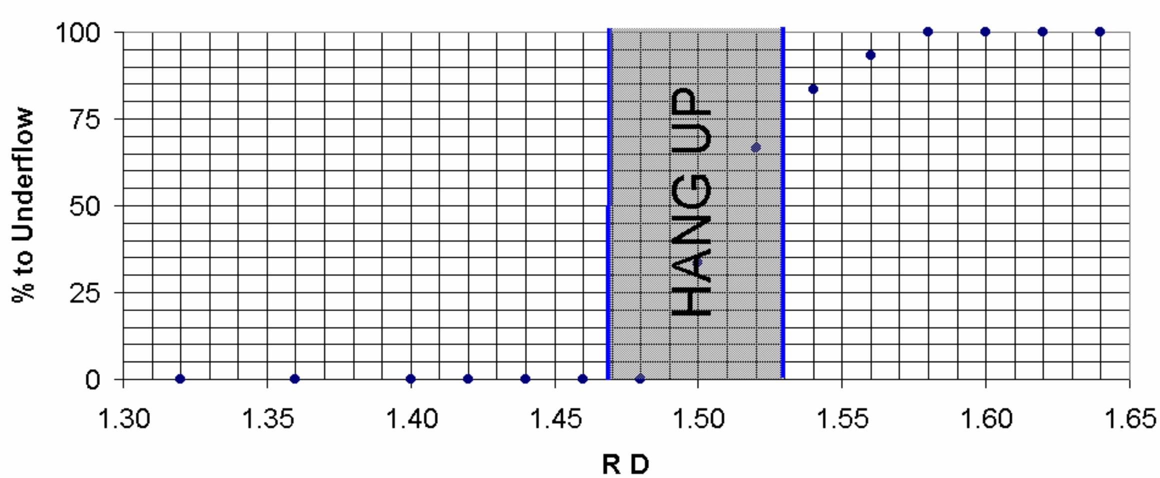
Test ID	Module ID	Date	Time
Liberty	DMCs (all 6)	18-Jun-01	14:37 to 15:20
Feed Type	Plant Feed	HMC Feed	Tracer Size
	tph (ar)	tph/HMC (db)	32mm
	1500+/-50	94	
Diameters (inches)	Body	Vortex Finder	Apex
	26	10	7.6
Condition of	Bodies	Vortex Finder	Nozzles
	good	good	very good
Apex Alignment	Inlet Pressure	Gauge Posn	Head
fair	10 psi	-30 in below inlet	8.3 diameters
Magnetite	Overflow RD	Overflow RD	Underflow RD
Grade B	208A 1.295	208D 1.32	212A 1.62
Contamination	208B 1.30	208E 1.32	212B 1.64
cannot be	208C 1.30	208F 1.325	
determined			

Other Operating Conditions / Observations

Feed medium RD could not be accurately determined due to presence of coal.
Assembly of components has left "steps" up to 3/8", mostly "out" (see text).
Nominally -1/2", but includes particles up to 5".
HMC feed rate estimated from D&R screen oversize flows.
Head estimation assumes that the true medium RD was 1.45.
Pressure reading from dial gauge. Accuracy not checked.

R D	Number of Tracers . . . in Feed	retrieved from... Overflow unit A	Overflow unit B	Overflow unit C	Overflow unit D	Overflow unit E	Overflow unit F	Overflow Total	Underflow unit A	Underflow unit B	Underflow Total	Recovered b+c	**% to U/flow**
	a	A	B	C	D	E	F	b	A	B	c	d	
1.32	20	3	2	2	6	6	1	20	0	0	0	20	0
1.36	20	2	1	4	6	6	0	19	0	0	0	19	0
1.40	20	2	3	5	1	4	1	16	0	0	0	16	0
1.42	25	4	4	3	5	5	3	24	0	0	0	24	0
1.44	20	8	2	4	1	3	0	18	0	0	0	18	0
1.46	20	1	4	3	2	2	2	14	0	0	0	14	0
1.48	20	0	0	0	0	2	4	6	0	0	0	6	0
1.50	20	1	0	0	1	2	0	4	2	0	2	6	33
1.52	25	0	2	0	0	1	0	3	3	3	6	9	67
1.54	20	0	0	0	0	0	2	2	8	2	10	12	83
1.56	20	0	0	0	0	0	1	1	6	8	14	15	93
1.58	20	0	0	0	0	0	0	0	9	7	16	16	100
1.60	25	0	0	0	0	0	0	0	6	13	19	19	100
1.62	5	0	0	0	0	0	0	0	2	3	5	5	100
1.64	5	0	0	0	0	0	0	0	4	1	5	5	100
1.66	5	0	0	0	0	0	0	0	0	5	5	5	100
1.68	5	0	0	0	0	0	0	0	3	2	5	5	100
1.70	5	0	0	0	0	0	0	0	1	3	4	4	100
1.72	5	0	0	0	0	0	0	0	2	2	4	4	100
1.74	5	0	0	0	0	0	0	0	2	1	3	3	100
1.76	5	0	0	0	0	0	0	0	0	4	4	4	100
1.78	5	0	0	0	0	0	0	0	2	3	5	5	100
1.80	5	0	0	0	0	0	0	0	3	2	5	5	100
Known dropped													
		0	0	0	0	2	0		10	0			

Density Tracer Partition Curve



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30:**	**Cutpoint:** 1.51	**Ep:**	**0.015**

Table 2
Retrieval of Retained 32mm Tracers

R D	Floats Screens						Refuse Screens	
	A	B	C	D	E	F	A	B
1.36	0	0	0	1	n	n	0	0
1.40	0	0	0	0	o	o	0	0
1.42	0	0	0	0	t	t	0	0
1.44	0	0	0	0			0	0
1.46	0	2	0	0	k	k	1	0
1.48	1	4	2	1	n	n	0	1
1.50	1	3	0	1	o	o	1	1
1.52	1	0	0	0	w	w	3	4
					n	n		

8. SIZE-BY-SIZE PERFORMANCE

8.1 Predicted from Density Tracer Results and Medium Behavior

The partitioning behavior of coal particles larger than about 8 mm may be expected to approximate that of the 32 mm tracers. If tracers are retained, common experience is that the coal cutpoint is usually a little below the mid-point of the SG range of retention. In this case, however, data points plotted from those tracers not retained suggest a cutpoint of 1.51 SG units.

To predict the partition curves for smaller particles we will utilize the observation that there is a strong tendency for all the curves to pass through or close to a “pivot point” which occurs at a partition number tending to match the volumetric fraction of medium which reports to DMC underflow.

There is a strong phenomenological basis for this behavior which arises from the following points which relate to a DMC operating with a truly stable medium:

- There is no tendency for particles of density equal to the medium density to report preferentially to overflow or to underflow. Thus they are partitioned according to the volumetric split of medium.
- Due to fluid drag phenomena, very small particles (of any density) are also partitioned according to the volumetric split of medium.
- For particles of a density not equal to the medium density, the partition number for a small particle will be closer to the medium split than that for a large particle. This also relates to fluid drag and explains why Ep values increase with decreasing particle size.

Of course, particulate medium such as slurries of magnetite in water are never truly stable. Therefore, the estimates the volumetric split of medium are typically made by measuring the densities of feed, overflow and underflow medium and invoking the formula:

$$Volume\ \%\ to\ Underflow = 100\frac{Feed\ Medium\ SG - Overflow\ Medium\ SG}{Underflow\ Medium\ SG - Overflow\ Medium\ SG}$$

As has been noted, feed medium density at Plant C could not be accurately measured. As a fallback, the internal dimensions were used to estimate that the medium split (and pivot partition number) may have been around 10% to underflow.

An DMC performance model developed by the author (Wood, 1991) suggests that, except at exceptionally low pressures or exceptionally high medium viscosity, a single DMC can achieve the rather small size-by-size Ep values listed in Table 3. For “real-world” situations, to account for considerations such as the internal roughness of the DMCs, these are increased by 50 percent, and for Plant C they are also degraded by:

- a further 20 percent to account for the probable low pressure and for differences in internal geometries of the six DMCs, and
- an addition of 0.01 to account for the likely cutpoint differences occasioned by feed biases and by differences in internal geometries.

These considerations give the cutpoints and Ep values listed in Table 3 and illustrated in Figure 5. Cutpoint for the coarse fraction is assumed to be similar to that for 32 mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 10% to underflow.

8.2 Comparison with Partition Curves Based on Float/Sink Analyses

Over a 21 minute period immediately following the main part of the tracer test (and before retrieval of the retained tracers) multiple-increment coal samples were recovered from the drain-and-rinse screens associated with one battery of three DMCs. Measurements of medium density continued throughout and following both phases of testing.

The principal purpose of coal sampling and analysis was to generate size-by-size partition curves for comparison with predictions based on the density tracer results. The sample increments were timed and sample cutters of known width were used. This has allowed estimation of the t/h loadings on the drain-and-rinse screens. No serious bias between clean coal screen loadings was revealed. Dry-basis coal flows for the three DMCs were:

clean coal:	195 long tons per hour
refuse:	89 long tons per hour
reconstituted feed:	284 long tons per hour.

Assuming a mean density of 1.55, this equates to 62m^3/h per cyclone.

As noted above, the Krebs representative indicated that with 10" vortex finders and an inlet pressure head of 11.7 "cyclone diameters" the volumetric capacity of each unit should be 1655 gpm. This high value is due principally to the large inlets. If the local dial gauge was reliable and the head was actually 8.6 "diameters," the capacity would be approximately 1419 gpm (322m3/h). Thus the ratio of:

Medium / Coal = (322-62)/62 = 4.2/1.

This figure is quite acceptable and allows some latitude for distribution biases and for variations in the size distribution of plant feed.

Table 3 and Figure 5 show observed partition curves based on float/sink analyses as well as the predictions based on the tracer test. The comparison indicates a slight error in predicted cutpoint for the coarsest fraction. This is common and is thought to relate to the absorption of water and of float/sink liquids into the coal particles. For the other two size fractions the predictions match the float/sink data well.

Table 3.
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model x1.5 SG units	Predicted for Plant C from tracer test (see text) SG units		Observed for Plant C based on float/sink SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.005	1.51	0.016	1.54	0.020
-4 +2	2.8	0.020	1.546	0.034	1.563	0.038
-1+0.5	0.7	0.078	1.688	0.104	1.681	0.110

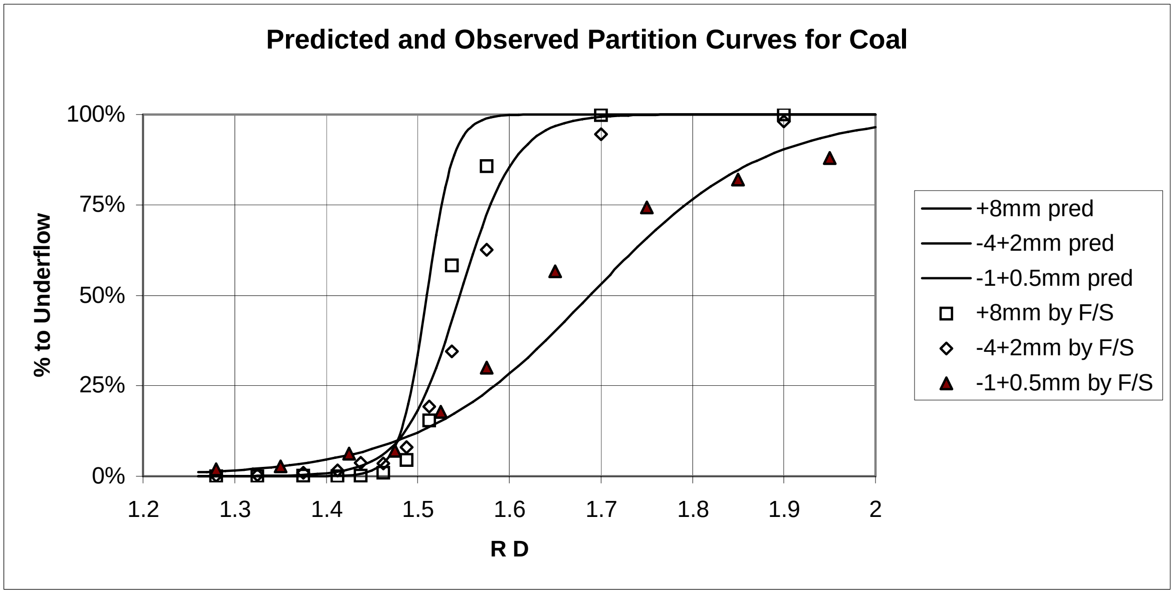


Figure 5.
The data points were derived from coal sampling and float/sink analyses. The curves indicate partition curves predicted from density tracer results. Predicted cutpoints for coarse particles are a little low, but all other predictions show a good match with the float/sink results.

9. POTENTIAL FOR YIELD IMPROVEMENT

9.2 Optimizing Partitioning Precision of the DMCs

Two possible avenues for improving partitioning performance suggest themselves. Inlet pressure should be maintained in the range 9 to 11 “diameters” and steps should be taken to minimize any cutpoint differences between the six DMCs. Apex diameters and overall condition of the DMCs were very similar but it seems likely that the asymmetrical feed distributors induce feed biases and consequent small differences in cutpoints. Potentially the size-by-size Ep values could be reduced to the values shown in Column 3 of Table 3. (Note that those Ep values for the coarser particles could not be readily resolved using float/sink analyses). Simulations show that by optimizing performance to achieve those Ep values, and then adjusting the feed medium density to re-achieve the original product ash content, the plant yield could be improved (but only by a very small amount). This result arises from the Massey Coal policy of running most DMC circuits so that cutpoints are high and the proportion of “near-gravity” material is small.

There are plans to replace the three-way splitters ahead of each bank of DMCs with units designed to produce less bias of feed. As described, this should give a slight improvement in partitioning efficiency. It would also give a small improvement in capacity for efficient partitioning because no individual cyclone would be fed significantly more coal than the other cyclones.

9.2 Matching DMC and Vessel Cutpoints

In Plant C, the DMC and vessel circuits contribute to a common product. In those circumstances and for a required product quality, yield is maximized if the two circuits operate at equal incremental ash (not instantaneous ash). That may be re-stated as "*If conditions are adjusted so that each circuit generates a slightly greater yield, the ash of the additional material from the circuits should be equal.*" For units which partition sharply (such as heavy medium vessels and cyclones) that condition is approximated if the cutpoints of both circuits (over their respective feed size ranges) are equal.

As has been recognized by personnel at the participating coal company, vessel cutpoints are typically close to the density of feed medium, while DMC cutpoints are usually higher than the feed medium density. For this reason, Plant C personnel generally aim for a DMC feed medium density 0.05SG units lower than that for the vessel. At the time of our trial the cutpoints for the DMC and vessel circuits were 1.60 and 1.65 SG units, respectively. The presumption would be that both cutpoints were around 1.65 SG but, as has been shown, the overall DMC cutpoint was only 1.55 SG units. Simulations will be conducted to assess the potential for improving yield by bringing both circuits to the same cutpoint.

10. CONCLUSIONS

The Plant C DMC circuit was tested using 32 mm density tracers. Coal and medium samples were also recovered. The resulting data and partition curves are presented, together with details of operating conditions and other observations. While some tracers were buried in the coal or refuse beds on the drain-and-rinse screens and were lost, those losses were not sufficient to seriously compromise the results.

Many ancillary observations and measurements were made for correlation with the observed tracer partitioning performance and for prediction of size-by-size coal partitioning. The circuit flowsheet which was made available was found to misrepresent the current plant in a number of respects. The work environment was less than ideal with considerable spillage in many areas, but has been improved in the past year.

Plant observations included inspection of the DMC internals, which were in good condition; though underflow discharge arrangements were somewhat restrictive. To reduce wear, a bit more attention could be paid to correct alignment of DMC components during assembly. Operating pressure was a little low at 10 psi, equivalent to a medium head of 8.3 "cyclone diameters." Plant maintenance personnel indicated that the 400 HP drive motor has been replaced with a 500 HP unit and the motor pulley size increased from 18" to 18.6" and then to 19". This allows operation at a pressure of 12 psi, equivalent to about 9.5 "diameters" which is in the recommended range of 9 to 12 "diameters." Medium density cannot be reliably measured or monitored because there is no line which carries feed medium without raw coal.

Operators expressed concern about high magnetite consumption. Probable reasons for the excessive consumption at that time were inadequate rinsing on drain-and-rinse screens and low levels in a number of magnetic separator tubs.

Some density tracers of intermediate densities were retained in at least four of the six DMCs. Particle retention is not, in itself, a problem. This is especially true at Plant C where the coal feed is less than ½ inch.

The tracers showed that:

- the separation density for coarse particles was around 1.5 SG units,
- there was no serious misplacement of float 1.45 SG to refuse or of sinks 1.60 SG to refuse, and
- the cutpoint cannot be accurately controlled because the feed medium density cannot be reliably monitored.

Given a density tracer partition curve, the author usually predicts the corresponding partition curves for various size fractions of coal only after estimating the volumetric split of medium between underflow and overflow. That estimate is based on the densities of feed, overflow and underflow medium but, as has been noted, feed medium density could not be reliably determined, so the estimate was made using an inferior method based on DMC orifice dimensions. The predicted coal partition curves are presented.

One of the advantages claimed for density tracers is that, unlike conventional sampling and float/sink analyses, partition curves are typically available in less than one hour from commencement of the test. This allows any remedial action to be quickly undertaken to stem any observed loss of product. That advantage was amply demonstrated in the current case where, 12 months after sampling, sample sieving and float/sink work for the seven circuits involved in this project were completed only a few months ago. It must be said, however, that under very detailed instructions, Precision Testing Laboratories have conducted the float/sink work with great care and precision. The data are excellent. The size-by-size partition curves for the plus 2 mm coal follow the predictions quite closely. Only for the minus 1 mm material is there a significant discrepancy which is attributed to a combination of coal degradation during sampling and sample processing, loss of some particles through the drain-and-rinse screens and the poor estimate of the medium split.

As part of the test program, a hand-held sieve was fabricated and tested for the removal of coal from the slurry stream from which Marcy gauge samples are recovered. The trial was successful, and consideration should be given to making a permanent installation to allow more reliable calibration of the nucleonic density gauge.

The most serious problem observed at Plant C was the discrepancy in cutpoints of the vessel (probably around 1.65 SG units) and DMC circuits (around 1.50 SG units). This reduces overall yield at any target ash and arises principally from the poor measurement and control of DMC medium density and hence of cutpoint.

APPENDIX I-D

Detailed Follow-Up Reports
Plant Site D

FINAL PLANT ASSESSMENT REPORT
"DENSE MEDIUM CYCLONE OPTIMIZATION"

REPORT FOR PLANT SITE "D"

Project Period:

December 14, 2000 – December 30, 2004

DOE Project Number:

DE-FC26-01NT41061

Participating Organizations:

Virginia Tech
Mining & Minerals Engineering
100 Holden Hall
Blacksburg, Virginia 24061

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Indooroopilly
Queensland 4068, Australia

Precision Testing Laboratory
P.O. Box 1985
Beckley, West Virginia 25801

Massey Energy Company
315 70th Street
Charleston, West Virginia 25304

1. INTRODUCTION AND OBJECTIVES

This study was conducted as part of the project “Dense Medium Cyclone Optimization” funded by the U.S. Department of Energy. Team members are:

- Virginia Polytechnic Institute and State University
- Massey Coal Services
- Partition Enterprises Pty Ltd
- Precision Testing Laboratories

Objectives were:

- to determine whether useful performance data and performance estimates for all sizes can be quickly generated using density tracers supported by other on-the-spot observations including Marcy measurements of the densities of feed, overflow and underflow media,
- to compare such estimates with the results of conventional float-sink analyses which are much more time-consuming and expensive, and
- to use the tracer results to identify any inefficiencies and develop recommendations for corrective actions.

If the density tracer technique with its rapid results and low cost is demonstrated to be useful in maximizing and maintaining yields, it could become a valuable adjunct to, or partial replacement of, conventional float-sink testing.

2. THE CIRCUIT AND FEED COAL

The plant incorporates a heavy medium drum, two heavy medium cyclones as well as spirals and froth flotation. Key aspects are generally as detailed in the CLI flowsheet (Drawing No FS-001 Rev 2).

DMC feed size is nominally 0.5 inches x 14 mesh (12.5 x 1.0 mm). Samples recovered in this study showed it to be 95% minus 0.5 inches and 4% minus 1.0 mm. These are in good agreement with the process design, and the latter figure indicates reasonably effective desliming.

The DMCs were said to treat about one third of the plant feed, though the flowsheet puts the figure at 47 percent (560 tph of 1200 tph). Timed samples recovered in this study put it at only 23 percent.

The circuit incorporates a correct medium sump and wing-tank arrangement. Density control is by water addition to the correct medium pump suction, and the nucleonic density gauge is located downstream of that pump where it can monitor medium without feed coal. The circuitry for control of medium density and sump level requires a bleed of circulating medium which is directed to a medium regeneration circuit based upon magnetic separators.

In the Plant D plant that bleed is taken from the medium head box and therefore is not biased as is the case when it is taken directly from floats or sinks drain-and-rinse screen underflow.

A two-way distributor is used to split slurry between the DMCs (Figure 1). It is symmetrically arranged, but has a bend of about 70 degrees immediately prior to the feed entry point. Such bends can introduce a swirling action which causes segregation of medium and of coal, but especially of stone. Test results in Section 6 do indicate a bias in feed to the DMCs consistent with such segregation.

Sampling tools were custom-manufactured for this circuit (Figure 2). Plant personnel were most obliging in cutting out superfluous sections of launder covers for some screens to allow access.

Figure 1.
The distributor which splits feed slurry between the two DMCs is symmetrically arranged but is preceded by a bend. This is a probable contributor to a feed bias which affects coal yield.

Figure 2.
Coal sampling arrangement for a drain-and-rinse screen.

The drain-and-rinse screens were lightly loaded. The flow rates of rinse water were low and its distribution was generally poor (Figures 3 and 4). At the June 2001 plant feed rates there may be a case for putting two clean coal screens and one refuse screen on standby, re-directing the available rinse water to the remaining three screens and refurbishing the spray systems. This would save on power and maintenance costs and may also reduce magnetite losses. This approach should be re-assessed in view of the planned increase of 25 percent in plant throughput. That increase was to follow commissioning of a longwall miner in the Cedar Grove seam which has probably, by now, been implemented.

Figure 3.
One example where flowrates and distributions of rinse water were poor.

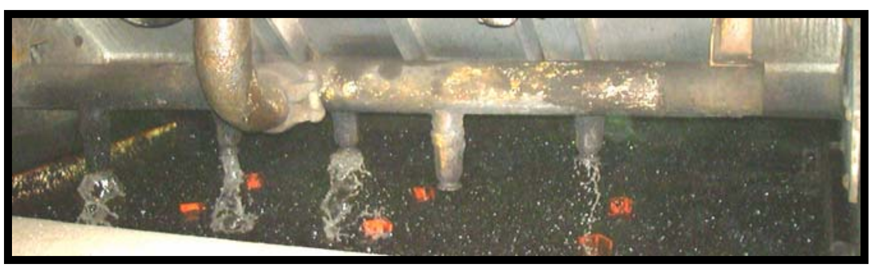


Figure 4.
Another example where flowrates and distributions of rinse water were poor.

3. DMC DIMENSIONS

The twin 800 mm DMCs are of Multotec design and manufacture with a scrolled involute entry. Virginia Tech personnel did not have the opportunity to inspect the DMC internals for wear and for “steps” at the joints where the various components are bolted together. However, Multotec, South Africa, has advised that the DMCs are Model MA800-20-1/A-A/275 with a vortex finder ID of 345mm (which conforms with the Dutch State Mines standard of the 1950s).

Multotec also forwarded Drawing MA800-20-1/B-A/275 with Barrel 1, 6D. It shows an inlet ID of 206 mm and a cylindrical body length of 1280 mm. Upon comparison with typical DMC design, the author offers the following opinions:

- The inlet is large, giving increased capacity at the cost of a small increase in Ep for fine particles.
- The apex is reasonably large. This directs a relatively large proportion of medium to underflow, as is appropriate for moderate-to-low yield coals.
- The cylindrical section is long, providing a further increase of capacity and directing an even larger proportion of medium to underflow.

4. OPERATING PRESSURE

Operating pressure is monitored by an electronic transducer. Calibration or test information on the latter could not be obtained, but such units are usually reliable. During the test period the pressure was recorded as 14 psi +/- 1 psi. Making due allowance for the transducer location, the DMC diameter and the estimated slurry density, this converts to a pressure head, as defined by Dutch State Mines personnel in the 1940s, of 6.1 “cyclone diameters.” This is considerably below the range of 9 to 11 “diameters” usually recommended by the author. It reduces medium flows, tends to slightly reduce partitioning efficiency (increase Ep) and further increase the proportion of medium reporting to underflow.

As noted in the Summary, the problem of low pressure has now, to a degree, been rectified.

5. MEDIUM DENSITY MONITORING AND CONTROL

A calibration check of the plant Marcy gauge showed it to be reasonably accurate, reading only approximately 0.005 SG units high.

The nucleonic gauge appeared to be reading about 0.015 SG units higher than the Marcy gauge and fluctuating over a range of +/-0.03 SG units. A recalibration would be somewhat beneficial, but the precision of automatic control is adequate in view of the high operating density and the consequently low percentage of “near-gravity” material in the feed.

6. DENSITY TRACER TESTS AND RESULTS

6.1 Main Test

This test was conducted using the relatively small 16 mm tracers (5/8”) because the low screen loadings allowed adequate retrieval rates. Preliminary or “sighting” tests had shown that the cutpoint was only slightly higher than the feed medium density and that there was little or no retention of “near-gravity” particles in the DMCs. This allowed a suitable range and number of tracers to be selected for the main test.

There were delays, first while awaiting the feed blend preferred by plant management and then for a brief problem with medium density control. The tracer test eventually commenced on June 12, 2001 at 15:58 and spanned a period of 50 minutes. Recovery of coal samples and replicate determinations of the densities of feed, overflow and underflow media extended beyond that time and the latter were interrupted while conditions were re-established following a brief loss of feed to the plant.

Results of the tracer test are presented in Table 1.

The differential between the densities of overflow and underflow media was only 0.20 SG units – a value around 0.35 is more common. This result would arise from the large inlet area, the large ratio of apex to vortex finder and the low inlet pressure. As is normally the case in such circumstances, the offset between feed medium density and cutpoint is also small at 0.03 SG units.

Clearly there was no gross misplacement of very low density particles to sinks or of very high density particles to floats. Inspection of the tracer distributions reporting to individual screens suggests that both DMCs had very similar cutpoints but that Unit 2 had a small low-density tail. This indicates minor misplacement of low-density particles to refuse and will be further discussed below.

The overall Ep value of 0.016 SG units is poor for this plant, especially in view of the similar cutpoints for the two DMCs. Values of less than 0.01 SG units are commonly achieved, even for multi-separator circuits such as this. The author considers the principal reasons to be the low operating pressure, the biased distribution of feed and, perhaps, differing degrees of wear in the two DMCs.

Coal flow from the desliming screens could not be readily determined. However, the coal sample increments from the drain-and-rinse screens were timed and a custom-built sampling tool of known width was used. Following weighing and processing of the samples, this allowed the flow rate from each drain-and-rinse screen to be estimated. The results are presented in Table 2.

There appears to be a strong bias for the feed distributor to direct high-density material to DMC 2 and a lesser bias directing low-density particles away from DMC 2. As a result, DMC 2 is highly loaded in terms of sinks material.

Table 1.

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

Long Fork Prep Plant - June 2001

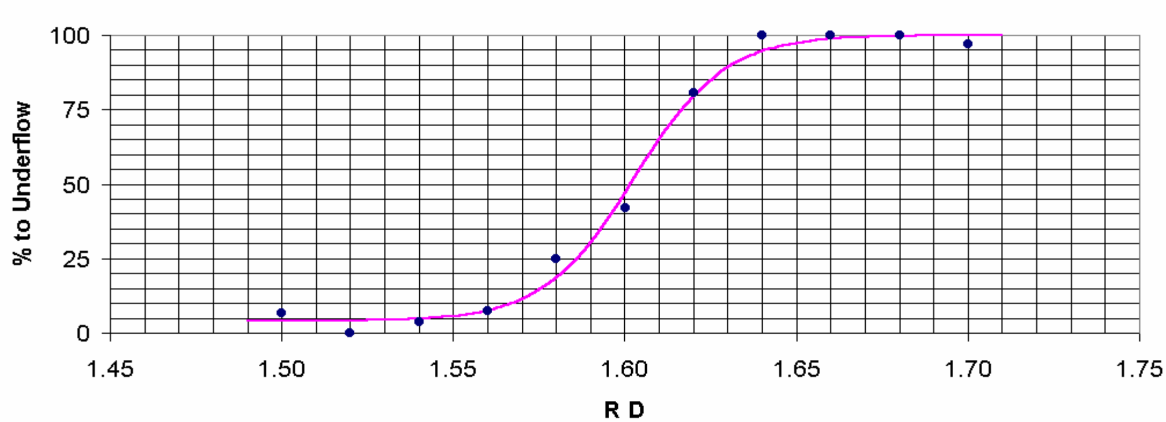
Test ID	Module ID	Date	Time
Longfork	DMCs	June 12, 2001	15:58 to 16:48
Feed Type	Plant Feed tph	Circ Feed tph	Tracer Size
Cedar Grove/	1200 +/-70	262	16
Pond Creek	tph (ar)	tph (db)	mm
Diameters of	Body	Vortex Finder	Apex
(mm)			(as new)
Unit 1	800	345	275
Unit 2	800	345	275
Condition of	Body	Vortex Finder	Apex
	n/a	n/a	n/a
	n/a	n/a	n/a
Apex Alignment	Inlet Pressure	Gauge Posn	Head
n/a	15	71	6.1
	+/-0.5 psi	ins below inlet	diameters
Magnetite	Feed RD	Overflow RD	Underflow RD
Grade B	1.57	CC1 1.47	Ref 1 1.67
		CC2 1.48	Ref 2 1.68
		CC3 1.47	
		CC4 1.49	

Other Operating Conditions / Observations

Marcy gauge was well calibrated (reading approx 0.005 high).
Operating pressure too low at 6.1 "diameters".
Tracers tended to report to refuse in groups, but small differential between underflow and overflow RD is not consistent with surging.
Small differential can arise from low pressure and large apex diameter and is consistent with
* the small offset between feed medium density & cutpoint
* the poor Ep

R D	Number of Tracers . . .										**% to**
	in	retrieved from...							Recov		**U/flow**
	Feed	Overflow					Underflow		ered	%	
		unit	unit	unit	unit	Total	unit	unit	Total	b+c	Lost	
	a	1	2	3	4	b	1	2	c	d		
1.50	40	14	5	3	6	28	0	2	2	30	25	7
1.52	40	10	4	6	9	29	0	0	0	29	27.5	0
1.54	40	10	1	6	9	26	0	1	1	27	32.5	4
1.56	40	9	2	5	9	25	0	2	2	27	32.5	7
1.58	40	7	5	3	12	27	2	7	9	36	10	25
1.60	40	8	2	2	6	18	3	10	13	31	22.5	42
1.62	40	1	2	0	4	7	11	18	29	36	10	81
1.64	40	0	0	0	0	0	8	29	37	37	7.5	100
1.66	40	0	0	0	0	0	14	19	33	33	17.5	100
1.68	40	0	0	0	0	0	8	30	38	38	5	100
1.70	40	0	1	0	0	1	7	26	33	34	15	97
Known dropped												
		4	2	1	6		4	4				

Density Tracer Partition Curve



PARTITIONING RESULTS	Coal Loss (%) at RD 1.30:	4	Cutpoint:	1.60	Ep:	0.014

Table 2.
DMC Flowrates and Yields

	Oversize Flow long t/h (db)	**Moisture Content** %
Clean Coal Screen 1	47	15
Clean Coal Screen 2	32	13
Clean Coal Screen 3	16	16
Clean Coal Screen 4	23	17
Refuse Screen 1	45	11
Refuse Screen 2	99	9
Derived Results (dry basis)		
	DMC 1	**DMC 2**
Clean Coal (lt/h)	63	55
Refuse (lt/h)	45	99
Recon Feed (lt/h)	108	154
Yield %	58	36

Both the tracer and float-sink results showed that partitioning was only moderately effective in terms of Ep. This would be attributable, at least in part, to the low operating pressure. More importantly, DMC 2 was losing some low-density particles to refuse. This was probably a case of floats overload (insufficient flow of medium to the vortex finder to carry out all floats material). The reasons may be:

- low feed medium flow due to low pressure,
- low split of medium to overflow due to low pressure and large apexes, and/or
- high loading of sinks dragging even more of the medium to underflow (further depleting overflow).

6.2 Follow-Up Test

Follow-up discussions were held on site with the plant superintendent. The DMC feed pump has been sped up. With a medium density of 1.55, a pressure of 20 psi can now be maintained. This equates to 8.9 “cyclone diameters” of medium head, bringing it almost to the recommended range of 9 to 12 diameters.

Following installation of a longwall, the plant has now been upgraded for routine operation at 1500 tph.

The author had 16mm tracers available on the day of the visit. It was decided to conduct a brief test in an attempt to determine whether the pressure increase had been effective in eliminating the misplacement of 4 percent of clean coal. Unfortunately, at the higher feed rate, retrieval rates of the small tracers were poor, so the detailed results will not be presented here. The author can only state his opinion that, based on the scant data, it is likely that the pressure increase has eliminated the misplacement of low-density coal. However, the partitioning efficiency (as defined by Ep) is still poor and the offset between feed medium density and cutpoint is still unusually small.

While a further increase of pressure would be beneficial, the focus of attention should now turn to the apex pieces. It seems likely that the original apex diameter of 275 mm was a little too large for this application and that they have probably suffered considerable wear since installation.

It is strongly recommended that the apexes be inspected and, if appropriate, replaced with apexes of 275 mm or smaller. If Plant D personnel care to inspect the apexes and record their diameters and condition, the author will be pleased to discuss appropriate replacements.

7. SIZE-BY-SIZE PERFORMANCE

7.1 Predicted from Density Tracer Results and Medium Behavior

The partitioning behavior of coal particles larger than about 8mm may be expected to approximate that of the 32 mm tracers. To predict the partition curves for smaller particles we will utilize the observation that there is a strong tendency for all the curves to pass through or close to a “pivot point” which occurs at a partition number tending to match the volumetric fraction of medium which reports to DMC underflow.

There is a strong phenomenological basis for this behavior which arises from the following points which relate to a DMC operating with a truly stable medium:

- There is no tendency for particles of density equal to the medium density to report preferentially to overflow or to underflow. Thus, they are partitioned according to the volumetric split of medium.

- Due to fluid drag phenomena, very small particles (of any density) are also partitioned according to the volumetric split of medium. For particles of a density not equal to the medium density, the partition number for a small particle will be closer to the medium split than that for a large particle. This also relates to fluid drag and explains why Ep values increase with decreasing particle size.

Of course, particulate media such as slurries of magnetite in water are never truly stable, and the volumetric split of medium is typically determined by measuring the densities of feed, overflow and underflow media and invoking the formula:

$$Volume\ \%\ to\ Underflow = 100\,\frac{Feed\ Medium\ SG - Overflow\ Medium\ SG}{Underflow\ Medium\ SG - Overflow\ Medium\ SG}$$

In this case:

$$Volume\ \%\ to\ Underflow = 100\,\frac{1.57 - 1.478}{1.675 - 1.478} = 47\%$$

An DMC performance model developed by the author (Wood, 1991) suggests that, except at exceptionally low pressures or exceptionally high medium viscosity, a single DMC can achieve the rather small size-by-size Ep values listed in Table 2. For “real-world” situations, accounting for internal roughness of the DMCs and the inaccuracies inherent in float-sink procedures, these values are increased by 50 percent and, for Plant D, they are further degraded:

- by an arbitrary multiplier of 1.5 to account for the low inlet pressure, and
- by an addition of 0.005 to account for the cutpoint difference of 0.01 between the two DMCs.

These considerations give the cutpoints and Ep values listed in Table 3 and illustrated in Figure 5. Cutpoint for the coarse fraction is assumed to be similar to that for 32 mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 47% to underflow.

Table 3.
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model x1.5 SG units	Predicted for Plant D from tracer test (see text) SG units		Observed for Plant D based on float-sink SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.005	1.600	0.012	1.59	0.02
-4 +2	2.8	0.020	1.605	0.034	1.60	0.03
-1+0.5	0.7	0.078	1.615	0.104	1.59	0.11

7.2 Comparison of Predicted Partition Curves with Float/Sink Results

In conjunction with the tracer tests, coal samples were also recovered and their analyses have recently been completed. Those data have been used to generate partitioning results for three size fractions of coal. Derived parameters (cutpoint and Ep) are included in Table 3. Figure 5 shows a comparison between the partition curves predicted from the tracer test results and the actual float-sink partition points.

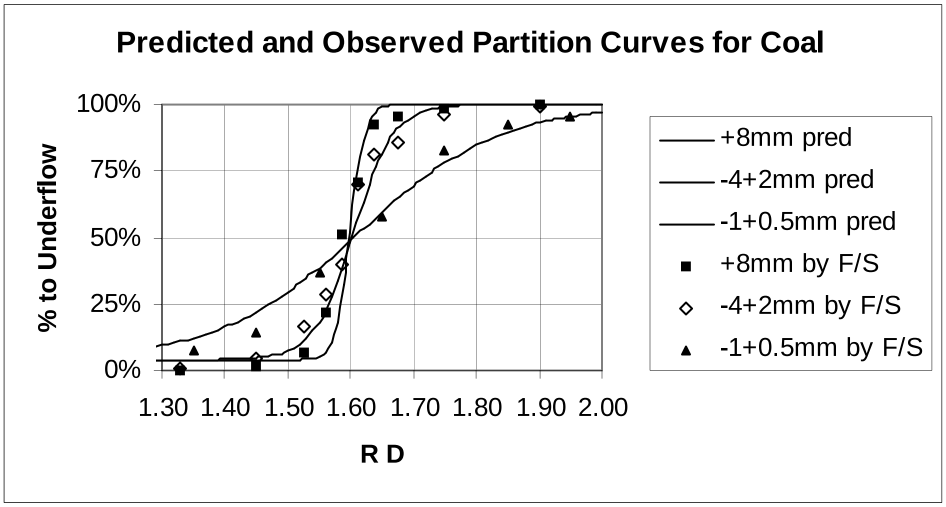


Figure 5.
The data points were derived from coal sampling and float-sink analyses. The curves indicate partition curves predicted from density tracer results. In broad terms, the agreement is good. The float-sink-derived data points confirm the observation from tracers that there was a low-density "tail" indicating some by-pass of coal to refuse.

8. POTENTIAL FOR YIELD IMPROVEMENT

8.1 Optimizing Partitioning Precision of the DMCs

Four inter-related avenues for improving DMC partitioning and yield suggest themselves.

Option 1: Eliminate the Low-Density "Tail" in the partition curve for DMC 2.

The coal loss identified by that tail could probably be eliminated by reducing the bias which appears to be caused by the feed splitter. It may be possible to achieve this by re-arranging pipework to ensure a long vertical run into the distributor. A rule-of-thumb defines "long" as being at least twenty pipe (inside) diameters. Another approach would be to install a single DMC of greater capacity.

Ideally, one of the above steps should be taken, but another means of eliminating the tail may be to simply operate at higher inlet pressure (and greater flow rates and less crowding). The recommended range is 9 to 12 "cyclone diameters." A disadvantage is that this action would probably accentuate the observed small difference in DMC cutpoints. At the planned higher throughputs increased pressure may not be sufficient to eliminate the tail and one of the above two actions may also be required.

Option 2: Equalize Cutpoints for the Two DMCs.

Given that the apexes continue to be maintained in good repair and near-equal diameter, this would be best achieved by eliminating the feed bias by one of the two approaches described above.

Option 3. Reduce Ep Values for each size fraction

It is likely that the above-recommended increase in pressure would also achieve this end.

Option 4. Manipulate the Slippage of Cutpoint with particle size

In the circumstances tested, the estimated medium split to underflow ratio was very high at 47% (vol/vol). As a consequence, the cutpoints for all size fractions were very close to a common value (about 1.61 SG units). This was illustrated in Figure 5. Because the partition curves for the finer particles (e.g. –1+0.5 mm) are relatively flat, as one moves left along that curve to density 1.30, the curve has not yet fallen all the way to the 0% to underflow. Thus a significant portion of the abundant and high-quality coal particles at that density are misplaced to refuse. If the curves for finer particles could be shifted to the right, as is the case in most installations, that loss could be much reduced.

As well as reducing the size-by-size Ep values, the recommended increase in pressure will tend to:

- reduce the medium split to underflow,
- lower the pivot point where the curves intersect,
- cause a progressive increase of cutpoint with decreasing particle size, and
- reduce the losses described above.

The effects from pressure alone may, however, be rather small. A more direct means of achieving those goals would be to reduce the apex size. However, it is possible that this would exacerbate the issues of crowding and the low-density tail. Ideally any of the above steps should be taken one at a time with a density tracer test conducted after each change, in order to arrive at the optimal combination of operating conditions.

Through the above steps it should be quite possible to achieve the size-by-size Ep values listed in Column 3 of Table 2, coupled with a pivot point at, for example, 30 % to underflow (v/v). The effect on yield will be simulated. An ash *vs* density relationship should be used and size-by-size cutpoints manipulated to both maintain the 30% pivot point and achieve a product ash equal to that generated by the partition curves shown in Figure 5. From the simulations, predicted *absolute* values of yield and product ash content may have significant errors, but predictions of *changes* in those parameters are considered to be reliable.

The simulations are likely to show that if the situation detailed in the last paragraph were achieved, there would be a consequent DMC yield increase of just over 2 percent, with most of the advantage arising from elimination of the low-density "tail" in the partition curve.

8.2 Matching DMC and Vessel Cutpoints

In the Plant D plant the DMC and vessel circuits usually contribute to a common product. In those circumstances and for a required product quality, yield is maximized if the two circuits operate at equal incremental ash (not instantaneous ash). That may be re-stated as "*If conditions are adjusted so that each circuit generates a slightly greater yield, the ash content of the additional material from the circuits should be equal*." For units which partition sharply (such as heavy medium vessels and cyclones) that condition is approximated if the cutpoints of both circuits (over their respective feed size ranges) are equal.

As has been recognized by the participating industrial personnel, vessel cutpoints are typically close to the density of feed medium, while DMC cutpoints are usually higher than the feed medium density. For this reason, Plant D personnel generally aim for a DMC feed medium density 0.05 SG units lower than that for the vessel. On the day of our trials the DMC nucleonic density gauge was accurately calibrated, and the medium density was reasonably well controlled to the cutpoint of 1.57 SG units. The cutpoint was 1.60 (only 0.03 SG units higher than the feed medium density, but this will increase if, as recommended, inlet pressure is increased).

Let us assume that the vessel density was accurately monitored and controlled at 1.62 (1.57 + 0.05) SG units and that the cutpoint was close to that value. This is quite close to the DMC cutpoint, and in view of the small fraction of "near-gravity" material, the potential for further yield improvement by better matching of vessel and DMC cutpoints would be very small.

9. CONCLUSIONS

The Plant D DMC circuit was tested using 16 mm density tracers. Coal and medium samples were also recovered. The resulting data and partition curves are presented, together with details of operating conditions and other observations. While some tracers were buried in the coal or refuse beds on the drain-and-rinse screens and were lost, those losses were not sufficient to seriously compromise the results.

Many ancillary observations and measurements were made during the same month for correlation with the observed tracer partitioning performance and for prediction of size-by-size coal partitioning.

Although it is symmetrically arranged, the two-way distributor ahead of the DMCs was shown to bias the feed, preferentially directing coal to DMC 1 and refuse to DMC 2. This is probably attributable to the pipe bend immediately ahead of the distributor.

DMC operating pressure was low. The Marcy density gauge was accurate. The K-Ray appeared to be reading just a little high. In the face of normal plant disturbances the density control system allowed the feed medium density to fluctuate as much as +/-0.03 SG units. This is not serious while operating density continues to be greater than 1.5 SG units.

One of the advantages claimed for density tracers is that, unlike conventional sampling and float-sink analyses, partition curves are typically available in less than one hour from commencement of the test. This allows any remedial action to be quickly undertaken to stem any observed loss of product. That advantage was amply demonstrated in the current case where, 12 months after sampling, sample sieving and float-sink work for the seven circuits involved in this project were completed only a few months ago. It must be said, however, that under very detailed instructions, Precision Testing Laboratories have conducted the float-sink work with great care and precision.

Based on the density tracer partition curve and Marcy determinations of the densities of feed, overflow and underflow media, predictions were made of the forms of partition curves for a number of coal size fractions down to 0.5 mm. When float-sink analyses were finally completed, partition curves derived in the conventional way were shown to match the predictions with acceptable accuracy. This generates confidence in the ability of the density tracer technique to provide accurate estimates of DMC performance.

Cutpoints for the vessel and DMCs were similar, as is desirable in seeking to optimize overall plant yield.

Both the tracer and float-sink results showed that partitioning was only moderately effective in terms of Ep. This would be attributable, at least in part, to the low operating pressure. More importantly, DMC 2 was losing some low-density particles to refuse. This was probably a case of floats overload (insufficient flow of medium to the vortex finder to carry out all floats material). The reasons may be:

- low feed medium flow due to low pressure,
- low split of medium to overflow due to low pressure and large apexes, and/or
- high loading of sinks dragging even more of the medium to underflow (further depleting overflow).

A preliminary submitted to plant management recommended an increase in operating pressure which should eliminate the problem and increase DMC yield by about 2 percent. An increase to 20 psi has now been affected. This equates to 8.9 “cyclone diameters” of medium head which is almost in the recommended range of 9 to 12 “diameters.”

It seems that coal feed rate has also been increased. If yield losses still occur, a further recommendation would be to re-arrange feed piping to allow a long vertical run (ideally exceeding 25 feet) into the distributor.

An impromptu follow-up test with density tracers was also conducted at this site. While the results were not sound from a statistical viewpoint, they suggested that:

- The pressure increase has eliminated the misplacement of low-density coal.
- Partitioning efficiency (as defined by Ep) is still poor.
- The offset between feed medium density and cutpoint is still unusually small.
- While a further increase of pressure would be beneficial, the focus of attention should now turn to the apex pieces. It seems likely that the original apex diameter of 275 mm was a little too large for this application. The apexes have probably suffered considerable wear since the initial installation. These factors could cause the problems noted in Points 2 and 3 and would limit DMC capacity.

APPENDIX I-E

Detailed Follow-Up Reports
Plant Site E

FINAL PLANT ASSESSMENT REPORT
"DENSE MEDIUM CYCLONE OPTIMIZATION"

REPORT FOR PLANT SITE "E"

Project Period:

December 14, 2000 – December 30, 2004

DOE Project Number:

DE-FC26-01NT41061

Participating Organizations:

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1. INTRODUCTION

This study was conducted as part of the project "Dense Medium Cyclone Optimization" funded by the U.S. Department of Energy. Team members are:

- Virginia Polytechnic Institute and State University
- Massey Coal Services
- Partition Enterprises Pty Ltd
- Precision Testing Laboratories

2. THE CIRCUIT AND FEED COAL

The plant incorporates a heavy medium vessel and a module of two heavy medium cyclones. Key aspects are generally as detailed in the Bays, Inc flowsheet of 1994, but the fine DMC circuit is not in use.

DMC feed size is nominally –0.5 inch +14 mesh. Samples recovered in this study showed it to be 95% minus 15mm (about 9/16") and 2% minus 0.5 mm (about 28 mesh). The latter figure is indicative of effective desliming. Per the plant superintendent's direction, the test program was delayed until the plant was treating strip coal.

A draft tube sump is used and the sump discharge (including raw coal) is monitored by a nucleonic density gauge. The last several meters of the line are near-horizontal and incorporate a gentle bend before the line terminates in a two-way distributor (Figures 1 and 2). A small line from the distributor may be utilized to recover a sample of the medium plus raw coal.

3. DMC DIMENSIONS AND CONDITION

The twin 28 inch DMCs were manufactured by the Swormsco partners. A drawing of the units could not be obtained, but the manufacturer advised that the inlet area (as delivered) was 80 square inches and the vortex finder ID was 12 inches. The plant superintendent advised, at the time of testing, that one was about 8 months old and the other about 2 months old. He also advised that they had changed from 10.5 inch to 9 inch apexes "to direct more medium to overflow and to reduce the proportion of floats reporting to refuse." This seems entirely appropriate and brings the ratio of apex diameter to vortex finder diameter to 0.75:1, which is quite suitable for the Plant E situation where yield appears to be around 60 percent (see below).

Figure 1.
Feed arrangement and heavy medium cyclones showing the bend in the feed line ahead of the two-way distributor.

Figure 2.
Feed arrangement and heavy medium cyclones showing the feed sampling line and the position of the pressure transducer on the feed line to the far DMC.

The two DMC units were inspected and some details are presented later within this report in Table 1. They are fully tiled and all components were in good condition. There is a parallel section at the underflow discharge point. The author considers this to be a valuable feature to maintain the effective apex diameter over many months of service. A little more care could have been taken during assembly of the number 2 unit (Figure 3), but the resulting “inward steps” are not large and would have little effect on partitioning performance.

In each cyclone the parallel apex section does not discharge freely into a large underflow box. Rather, it leads into another parallel section of approximately 1 inch greater diameter which, in turn, leads into a semi-circular shroud (Figure 4). This arrangement appears to be rather restrictive and may influence the volumetric split of slurry between overflow and underflow in a poorly controlled manner. The rather long vortex finder/overflow pipes could have a counteracting effect. These factors can influence the split of medium between overflow and underflow and thus the offset between feed medium density and cutpoint.

Figure 3.
Components of the No. 2 DMC could have been assembled with a bit more attention to alignment to avoid "steps".

Figure 4.
A short parallel section at the apex is desirable, but in these units the parallel section is long and is followed by another parallel section and a restrictive shroud.

4. OPERATING PRESSURE

Operating pressure is monitored by a local dial gauge and an electronic transducer. Calibration or test information on the latter could not be obtained, but such units are usually reliable. During the test period the pressure was recorded as 11.3 psi +/- 0.1 psi. Making due allowance for the transducer location, the DMC diameter and the estimated slurry density, this converts to a pressure head, as defined by Dutch State Mines personnel in the 1940s, of 9 "cyclone diameters." This is just in the range of 9 to 11 "diameters" usually recommended by the author.

5. MEDIUM DENSITY MONITORING

In the Plant E plant configuration (as at Plant C), when feed is on, the slurry passing the nucleonic density gauge and the slurry sampled for check and calibration measurements by Marcy gauge both contain raw coal. Thus the density of the medium without coal cannot be readily determined during washing (In most heavy medium plants it can be determined). Nucleonic gauge output is displayed in the control cabin and recorded on a circular chart which is not accurate.

When operating without coal feed at Plant E a calibration may be effected, but it is rendered invalid the moment coal feed is introduced. The author observed that when coal feed was started, the nucleonic gauge signaled a brief density increase of approximately 0.05 SG units. As the operator manipulated medium streams, the *slurry* density came back to the level sought by the operator, but the effect on *medium* density was probably to reduce it significantly. The magnitude of that medium density error is highly dependent on feed rate, feed size distribution and on the mean density of the raw coal.

Quite apart from the above considerations, the density of a sample including coal cannot be reliably determined by Marcy scale because of the interfering and biasing effects of the coal which rapidly floats to the top of the slurry in the flask.

It is strongly recommended that means be sought to monitor and sample circulating medium, free of coal (apart from the minus 28 mesh contamination). Another peculiarity of the Plant E circuit is that floats drain medium is directed to the outer part of the DMC feed sump, while refuse drain medium flushes deslimed coal to the draft tube. Consideration could be given to combining the two drain flows, directing them through a nucleonic gauge and a sampling point before splitting the flow between the sump outer and the deslimed coal launder. If head room or other considerations preclude this, another alternative would be to re-engineer the sump as a "correct medium" sump with an attached wing tank and a second pump. A novel system used in one Australian plant may allow this with a relatively small pump to circulate the correct medium.

It was suggested that a very low cost (and less than ideal) fix may be to install a simple in-line screen in the pipe system which delivers medium samples for the Marcy gauge. That would allow a relatively coal-free sample to be obtained while feed was on. A small hand-held sieve was fabricated and tested in July 2002 (Figure 5). It successfully removed most of the coal from the sample stream and consideration should be given to making a permanent installation. An appropriate procedure for calibrating the nucleonic density gauge would need to be discussed.

Figure 5.
A hand-held sieve removes coal from sample streams for Marcy determinations of medium densities. Permanent installations should be considered.

6. MEDIUM DENSITY CONTROL

As detailed above, the current circuit configuration at Plant E makes it impossible to accurately monitor medium density. By definition it cannot, therefore, be accurately controlled. Operators advised that a system for automatic control of *slurry* density (not medium density) had been installed, but was no longer in use. Density control now relies on operator intervention to add more magnetite via a screw feeder and/or to manually adjust the position of a medium splitter. At the time of the trials, control was rather unstable. The plant superintendent advises that the situation has been much improved, partly through the installation of a larger line for water addition.

7. DENSITY TRACER TESTS AND RESULTS

Following several delays, the density tracer test was conducted using 32 mm cubic density tracers. Preliminary “sighting” tests had shown the range of tracer densities required and demonstrated a likelihood of retention, in the DMCs, of coarse particles, including tracers, of densities close to the cutpoint. To define a range of retention, large numbers of tracers are not required, so only 20 were used at most densities and only 5 at each of the higher densities. Full results, together with a tracer partition curve, are presented in Table 1.

The overall cutpoint was 1.65. The offset between medium density and cutpoint cannot be estimated because the former could not be reliably determined. However, if the nucleonic gauge showed 1.55, one may conjecture that the medium density may have been around 1.50, suggesting a rather large offset of 0.15 SG units.

While there was no gross misplacement of high-density or low-density tracers, the overall Ep of 0.021 was quite poor (with 32 mm tracers a result of less than 0.010 is quite achievable). Assessment of the tracer densities reporting to the individual floats screens provides strong evidence that unit 1 was partitioning at a lower density than unit 2, which also exhibited retention of tracers in the SG range 1.66 to 1.70. (Some of those tracers were recovered by briefly increasing the medium density so that they discharged to floats). The association of higher cutpoint with particle retention is common, and it is unlikely that the small observed differences in DMC dimensions could cause this performance difference. Possible culprits include a biased split of feed slurry arising from the gentle bend in the feed line immediately ahead of the distributor, and/or differences in the restrictive effects in the overflow and underflow discharge arrangements for the two DMCs (Section 3).

With a cutpoint around 1.65 SG, the offset difference would have only a small effect on yield. The SG range of retention was small and particles smaller than 20 mm (3/4 inch) are unlikely to be affected.

Table 1.

PARTITION ENTERPRISES PTY LTD

P.O. Box 512, Indooroopilly, Queensland 4068, Australia. ***Tel: +61 7 32781614*** ***Fax: +61 7 33792375***

Density Tracer Test Sheet

Omar Prep Plant - 7 June 2001

Test ID	Module ID	Date	Time
Omar	HMCs	07-Jun-01	10:28 to 10:52
Feed Type	Plant Feed	Circ Feed tph	Tracer Size
Strip coal Feeder 5	approx 810 stph (ar)	approx 225 stph (db)	32mm
Diameters (ins)	Body	Vortex Finder	Apex
unit 1	28	12	8.94 to 9.06
unit 2	28	12	8.94 to 9.09
Condition of	Body	Vortex Finder	Apex
unit 1	good	good	good
unit 2	good	good	good
Apex Alignment	Gauge Press.	Gauge Posn	Head (diams)
good	11.3	-44	9.0
good	psi	in below inlet	
Medium	Feed RD	Overflow RD	Underflow RD
Grade B	1.50	CC1 1.39	1.85
	guesstimate	CC2 1.38	

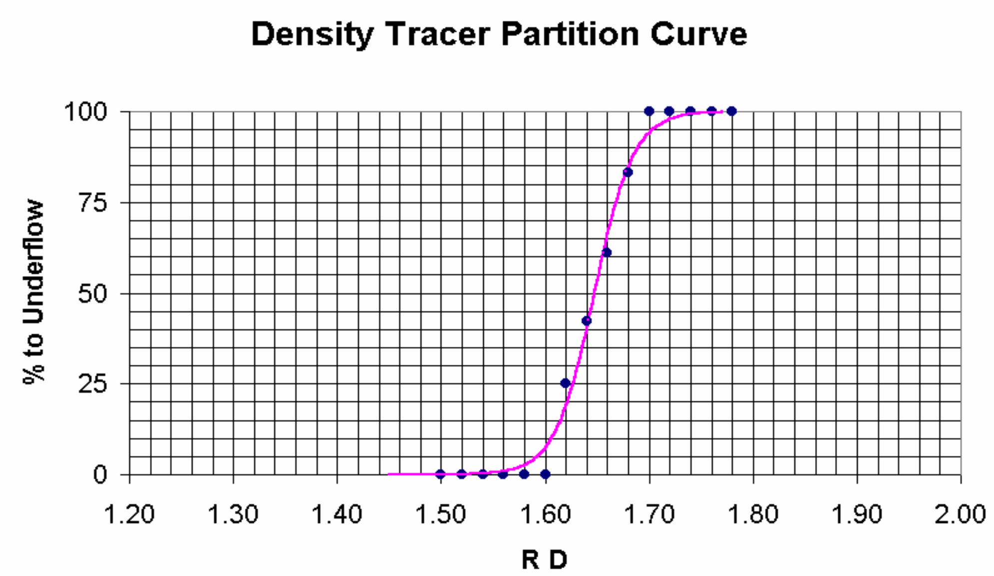
Other Operating Conditions / Observations

K-Ray showed 1.55 +/-0.01 but includes feed coal. Medium sample point also includes coal, so true medium density could not be determined. When coal feeder starts, K-Ray output briefly rises approximately 0.05 RD units.
HMCs fully lined with ceramic tiles. No 2 has small "steps" due to slight mis-alignment of components. Underflow shrouds may be restrictive and overflow pipes are long.
Unit 2 retains some tracers in RD range 1.66 to 1.70.
Medium bleed is from HMC overflow.

R D	Number of Tracers . . .						**% to**
	in	retrieved from...				Recov	**U/flow**
	Feed	Overflow			Under	ered	
		unit	unit	Total	Flow	b+c	
	a	1	2	b	c	d	
1.50	20	9	7	16	0	16	0
1.52	20	6	9	15	0	15	0
1.54	20	8	9	17	0	17	0
1.56	20	6	8	14	0	14	0
1.58	20	7	11	18	0	18	0
1.60	20	6	9	15	0	15	0
1.62	20	6	9	15	5	20	25
1.64	20	1	10	11	8	19	42
1.66	20	0	7	7	11	18	61
1.68	20	0	1	1	5	6	83
1.70	20	0	0	0	10	10	100
1.72	5	0	0	0	4	4	100
1.74	5	0	0	0	4	4	100
1.76	5	0	0	0	5	5	100
1.78	5	0	0	0	5	5	100

Preliminary tests had shown that retention was likely, so only 20 tracers were used at most RDs and only 5 at the higher RDs. If tested using float/sink techniques only, potential problems from particle retention would not be identified.

Known						
dropped	9	4		2		



PARTITIONING RESULTS	**Coal Loss (%) at RD 1.30:**	**0**	**Cutpoint:**	**1.65**	**Ep:**	**0.021**

8. SIZE-BY-SIZE PERFORMANCE

8.1 Predicted from Density Tracer Results and Medium Behavior

The partitioning behavior of coal particles larger than about 8 mm may be expected to approximate that of the 32 mm tracers. To predict the partition curves for smaller particles we will utilize the observation that there is a strong tendency for all the curves to pass through or close to a “pivot point” which occurs at a partition number tending to match the volumetric fraction of medium which reports to DMC underflow.

There is a strong phenomenological basis for this behavior which arises from the following points which relate to a DMC operating with a truly stable medium:

- There is no tendency for particles of density equal to the medium density to report preferentially to overflow or to underflow. Thus they are partitioned according to the volumetric split of medium.
- Due to fluid drag phenomena, very small particles (of any density) are also partitioned according to the volumetric split of medium.
- For particles of a density not equal to the medium density, the partition number for a small particle will be closer to the medium split than that for a large particle. This also relates to fluid drag and explains why Ep values increase with decreasing particle size.

Of course, particulate media such as slurries of magnetite in water are never truly stable, and the author usually estimates the volumetric split of medium by measuring the densities of feed, overflow and underflow media and invoking the formula:

$$Volume\ \%\ to\ Underflow = 100\frac{Feed\ \ Medium\ SG - Overflow\ Medium\ SG}{Underflow\ Medium\ SG - Overflow\ Medium\ SG}$$

As has been noted, feed medium density at Plant E could not be accurately measured. As a fallback, the internal dimensions were used to estimate that the medium split (and pivot partition number) may have been around 10% to underflow.

A DMC performance model developed by the author (Wood, 1991) suggests that, except at exceptionally low pressures or exceptionally high medium viscosity, a single DMC can achieve the rather small size-by-size Ep values listed in Table 2. For “real-world” situations these are increased by 50 percent and, for Plant E, they are further degraded due to the small offset observed between cutpoints for the two DMCs, giving the cutpoints and Ep values listed in Table 2 and illustrated in Figure 7. Cutpoint for the coarse fraction is assumed to be similar to that for 32 mm density tracers and cutpoints for the smaller fractions were determined by ensuring that all curves passed through a pivot point at 10% to underflow.

Table 2.
Coal Partitioning Performance Predicted from Density Tracer Test Results and Observed Partitioning Performance from Sample Analyses

Size Range mm	Mean Size mm	Ep from Wood model x1.5 SG units	Predicted for Plant E from tracer test (allowing for 0.03 difference in cutpoints) SG units		Observed for Plant E based on float-sink SG units	
			Cutpoint	Ep	Cutpoint	Ep
-16 +8	11.2	0.003	1.65	0.02	1.64	0.02
-4 +2	2.8	0.020	1.67	0.03	1.67	0.04
-1+0.5	0.7	0.078	1.75	0.09	1.86	0.10

8.2 Comparison of Predicted Partition Curves with Float-sink Results

In conjunction with the tracer tests, coal samples were also recovered and their analyses have recently been completed (Appendix II). Those data have been used to generate partitioning results for three size fractions of coal. Derived parameters (cutpoint and Ep) are included in Table 2. Figure 6 shows a comparison between the partition curves predicted from the tracer test results and the actual float-sink partition points.

There is a slight error in predicted cutpoint for the coarsest fraction. This is common and is thought to relate to the absorption of water and of float-sink liquids into the coal particles.

There is a significant error in the predicted cutpoint for the finest size fraction (-1 +0.5mm). Contributing factors probably include the loss of some of this material through the rejects drain-and-rinse screens and the fact that some of the small particles which reach he float-sink baths were generated by degradation from larger particles during the processes of sampling, storage, drying and sieving. A further factor may be that the estimate of medium split between DMC overflow and underflow is wrong. The float-sink curves suggest that the actual pivot point was less than 10%. The error in the medium split and in the pivot partition number may arise from the impediments to underflow discharge noted in Section 3. If the pivot point is reduced to an unreasonably low value of 1% to underflow, it may be seen that the predicted partition curve for fines more closely matches the observed values (Figure 7).

The true volumetric split of medium probably lies between the values of 1% and 10% to underflow, and this may prove an interesting issue for further investigation on the author's return to the USA in mid 2002. It is hoped that provision will be made for improved sampling of feed medium to allow a more reliable estimate of the split.

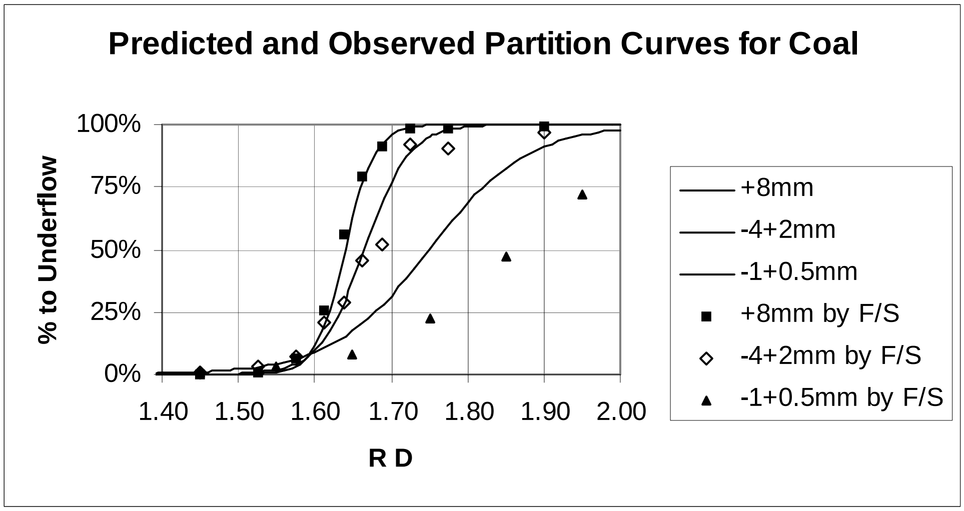


Figure 6.
The data points were derived from coal sampling and float-sink analyses. The curves indicate partition curves predicted from density tracer results. Causes of the apparent discrepancy include loss of particles through the drain-and-rinse screens, degradation during sampling and sample processing, and the inability to measure feed medium density and thus to estimate the volumetric split of medium between DMC underflow and overflow (see text).

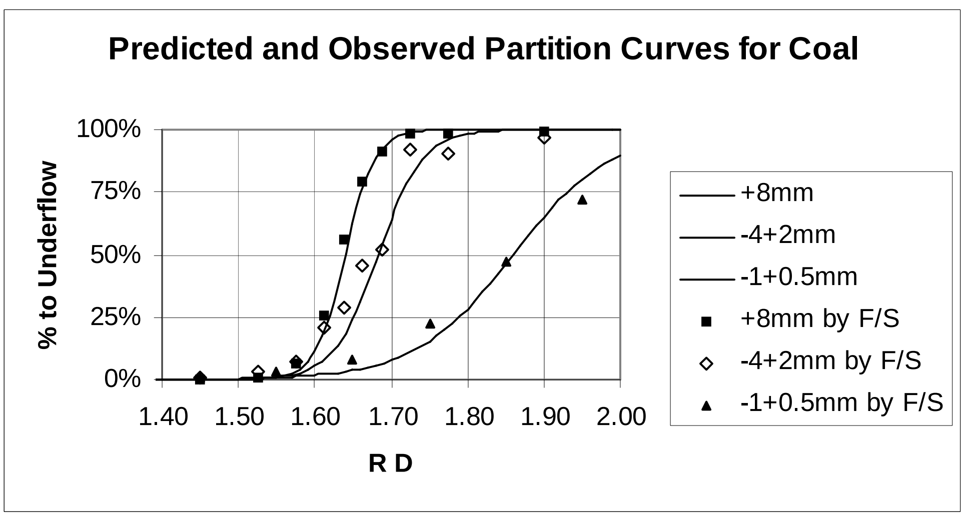


Figure 7.
By altering the volumetric split estimate, the partitioning predictions for fines more closely match the values derived from float-sink analyses. The matters of medium density measurement and volumetric split should be addressed in a follow-up investigation.

9. POTENTIAL FOR YIELD IMPROVEMENT

9.2 Optimizing Partitioning Precision of the DMCs

Two possible avenues for improving partitioning performance suggest themselves. The first is to take steps to equalize the cutpoints of the two DMCs (the tracer tests showed them to differ by approximately 0.03 SG units). Planned simulations utilizing the observed partitioning performance and raw coal characteristics are expected to show that by equalizing the cutpoints, and then adjusting the feed medium density to re-achieve the original product ash content, yield could be improved, but only by a small fraction of a percent. This arises from the policy of the management personnel of the participating company running most DMC circuits so that cutpoints are high and the proportion of “near-gravity” material is small.

The second possible avenue is to raise the pivot point to bring the cutpoints for the various size fractions closer together. The simplest way to achieve that outcome would be to use somewhat larger apexes, although this may carry a penalty in terms of reduced DMC capacity for efficient partitioning. In any case, simulations are likely to show that, in the Plant E circumstances, there would be no advantage. Raising the pivot point partition number would move the partition curve for fines so far to the left that some of the abundant floats 1.40 coal would be misplaced to refuse. Even following appropriate adjustment of the feed medium density there may be a slight *reduction* of yield.

9.2 Matching DMC and Vessel Cutpoints

In the Plant E plant the DMC and vessel circuits contribute to a common product. In those circumstances and for a required product quality, yield is maximized if the two circuits operate at equal incremental ash (not instantaneous ash). That may be re-stated as, “*If conditions are adjusted so that each circuit generates a slightly greater yield, the ash of the additional material from the circuits should be equal.*” For units which partition sharply (such as heavy medium vessels and cyclones) that condition is approximated if the cutpoints of both circuits (over their respective feed size ranges) are equal.

As has been recognized by company personnel, vessel cutpoints are typically close to the density of feed medium, while DMC cutpoints are usually higher than the feed medium density. To optimize overall plant yield, Plant E personnel generally aim for a DMC feed medium density 0.05 SG units lower than that for the vessel. On the day of our trials the vessel medium density cutpoint was 1.60 SG units. Cutpoint for a vessel is usually close to the density of its feed medium. Therefore, if the K-Ray was accurately calibrated and if the density control system was effective, one may estimate that the vessel cutpoint was around 1.60 SG units. However, the DMC cutpoint was approximately 1.67 SG units.

10. CONCLUSIONS

The Plant E DMC circuit was tested using 32 mm density tracers. Coal and medium samples were also recovered. The resulting data and partition curves are presented, together with details of operating conditions and other observations. While some tracers were buried in the coal or refuse beds on the drain-and-rinse screens and were lost, those losses were not sufficient to seriously compromise the results.

Many ancillary observations and measurements were made during the same month for correlation with the observed tracer partitioning performance and for prediction of size-by-size coal partitioning. Those observations included inspection of the DMC internals, which were in good condition, but underflow and overflow discharge arrangements were somewhat restrictive. Operating pressure was good. Medium density cannot be reliably measured or monitored because there is no line which carries feed medium without raw coal. The automatic density control system is not used, so control is affected, with moderate success, by operator intervention.

Given a density tracer partition curve, the author usually predicts the corresponding partition curves for various size fractions of coal only after estimating the volumetric split of medium between underflow and overflow. That estimate is based on the densities of feed, overflow and underflow media, but as has been noted, feed medium density could not be reliably determined, so the estimate was made using an inferior method based on DMC orifice dimensions.

One of the advantages claimed for density tracers is that, unlike conventional sampling and float-sink analyses, partition curves are typically available in less than one hour from commencement of the test. This allows any remedial action to be quickly undertaken to stem any observed loss of product. That advantage was amply demonstrated in the current case where, 11 months after sampling, sample sieving and float-sink work for the seven circuits involved in this project have only recently been completed. It must be said, however, that under very detailed instructions, Precision Testing Laboratories have conducted the float-sink work with great care and precision. The data are excellent. The size-by-size partition curves for the +2 mm coal follow the predictions quite closely. Only for the –1 mm material is there a significant discrepancy which is attributed to a combination of coal degradation during sampling and sample processing, loss of some particles through the drain-and-rinse screens and the poor estimate of the medium split.

The results show that while each DMC is partitioning with reasonable efficiency, the overall separation is degraded by the fact that they are separating at slightly different cutpoints. However, with the Massey Coal policy of operating the Plant E circuit at reasonably high density and product ash levels, the impacts on yield of that degradation and of the strong shift of cutpoint with particle size are very small.

DMC cutpoint is reasonably close to vessel cutpoint so from that point of view as well the plant was at near-optimal efficiency.

In order to obtain proper medium readings, a hand-held sieve was fabricated and tested for the removal of coal from the slurry stream from which Marcy gauge samples are recovered. The trial was successful, and consideration should be given to making a permanent installation.

Since these trials the water addition arrangement has been upgraded. This appears to have improved the stability of density control, but it is suggested that the system for automatic control of feed medium density be re-implemented. If true medium density were monitored, the desirable offset between the densities of medium fed to the DMCs and to the vessel should probably be increased from the present 0.05 SG units to a value in excess of 0.10 SG units, but further tests would be required to determine the correct value.

The DMC apex and shroud arrangements could be redesigned to avoid the possibility of problems arising from restricted egress of underflow.

The overall findings are that DMC partitioning performance was quite adequate, but that the above modifications would help to maintain that situation under changing conditions in the future.

APPENDIX II – Plant Partitioning Data

APPENDIX II-A

Partitioning Data for Plant A
(Coarse and Fine DMC Circuits)

Test Description:	CIRCUIT A1 - COARSE COAL HMC CIRCUIT				
Feed Coal Type:	70% White Kn (P), 30% Hernshaw	Plant Feed Rate (tph):	2280	Tracer Size (mm):	32
		Circuit Feed Rate(tph):	814	Tracer Shape:	Cubes

	Body	Vortex	Apex				
Manufacturer:	Deister	Deister	Deister	Inlet Pressure (psi):	16.5	Weighting (Y/N)?	N
Diameter (Inch):	28	12	3.58-8.94	Gauge Position (inch):	-29	SG Cutpoint (SG50):	1.424
Wear Condition:	Good	Good	Good	Head (Diameters):	10.5	Probable Error (Ep):	0.013
Part Alignment:			Fair	Magnetite Grade:	B	Low SG Offset:	0.000

Tracer	Tracer	Overflow (Clean Coal)							Underflow (Refuse)							Tracers	Tracers	Refuse	Fitted	Weight	Weighted
SG	in Feed	A	B	C	D	E	F	Sum	A	B	C	D	E	F	Sum	Collected	Lost	Partition	Partition	Factor	Error
1.32	40	11	5	8	3	11		38	0	0	0	0			0	0.95	0.05	0.00	0.00	0.10	0.00
1.36	40	8	8	4	6	9		35	0	0	0	0			0	0.88	0.13	0.00	0.00	0.10	0.00
1.40	40	7	8	8	2	10		35	1	0	2	0			3	0.95	0.05	0.08	0.12	0.10	0.00
1.42	40	4	3	5	4	5		21	4	7	5	2			18	0.98	0.03	0.46	0.42	0.46	0.00
1.44	40	1	2	1	3	3		10	9	12	3	4			28	0.95	0.05	0.74	0.79	0.26	0.00
1.46	40	0	0	0	0	0		0	13	12	6	6			37	0.93	0.08	1.00	0.95	0.10	0.00
1.48	40	0	0	0	0	0		0	10	11	11	6			38	0.95	0.05	1.00	0.99	0.10	0.00
1.50	40	0	0	0	0	0		0	8	15	6	9			38	0.95	0.05	1.00	1.00	0.10	0.00
1.52	40	0	0	0	0	0		0	14	10	7	8			39	0.98	0.03	1.00	1.00	0.10	0.00
1.54	5	0	0	0	0	0		0	1	1	1	2			5	1.00	0.00	1.00	1.00	0.10	0.00
1.56	5	0	0	0	0	0		0	2	2	1	0			5	1.00	0.00	1.00	1.00	0.10	0.00
1.58	5	0	0	0	0	0		0	3	0	0	2			5	1.00	0.00	1.00	1.00	0.10	0.00
1.60	5	0	0	0	0	0		0	1	0	2	2			5	1.00	0.00	1.00	1.00	0.10	0.00
1.62	40	0	0	0	0	0		0	11	17	5	5			38	0.95	0.05	1.00	1.00	0.10	0.00
1.64	5	0	0	0	0	0		0	2	1	2	0			5	1.00	0.00	1.00	1.00	0.10	0.00
1.66	5	0	0	0	0	0		0	2	1	2	0			5	1.00	0.00	1.00	1.00	0.10	0.00
1.68	5	0	0	0	0	0		0	2	1	2	0			5	1.00	0.00	1.00	1.00	0.10	0.00
1.70	5	0	0	0	0	0		0	3	2	0	0			5	1.00	0.00	1.00	1.00	0.10	0.00
Known Dropped		0	1	0	1	1		3	0	2	0	1			3					Total WSSQ:	0.01

Description: CIRCUIT A1 - COARSE COAL HMC CIRCUIT

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections: Real World	Ep Corrections: O&M Factors	Ep Corrections: Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1	0.01	0.012
16	8	11.31	0.003	1.5	1	0.01	0.015
8	4	5.66	0.007	1.5	1	0.01	0.020
4	2	2.83	0.013	1.5	1	0.01	0.030
2	1	1.41	0.026	1.5	1	0.01	0.049
1	0.5	0.71	0.052	1.5	1	0.01	0.088

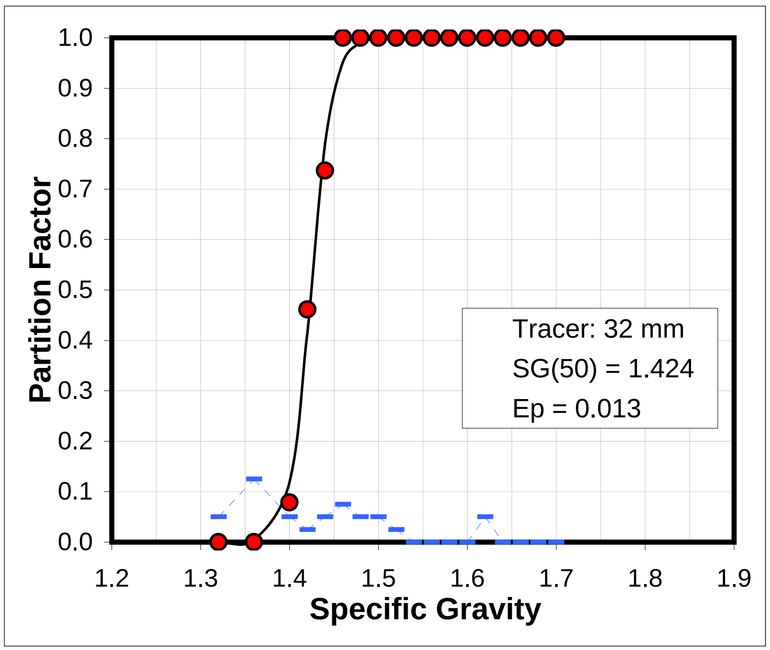
Comments:

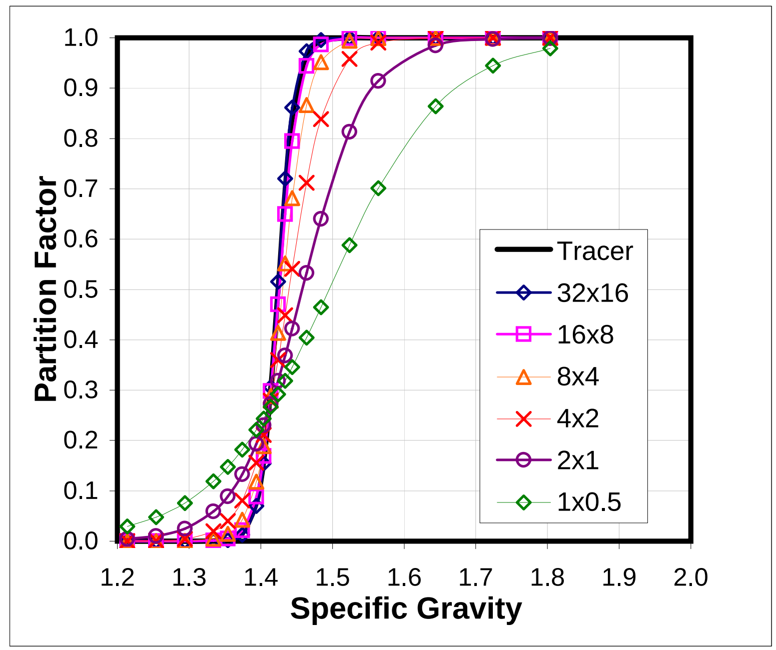
	SG	Split
O/F:	1.345	0.739
U/F:	1.599	0.261
Feed:	1.411	1.000

	SG	Split
Pivot:	1.412	0.261
O/F-U/F	0.25	

Obs.	Marcy Scale SG: Feed	O/F	U/F
1	1.41	1.34	1.6
2	1.415	1.34	1.59
3	1.415	1.35	1.61
4	1.405	1.345	1.595
5		1.35	
Avg.	1.411	1.345	1.599

Size	32	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.424	1.423	1.426	1.430	1.440	1.458	1.495
Ep	0.013	0.012	0.015	0.020	0.030	0.049	0.09
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





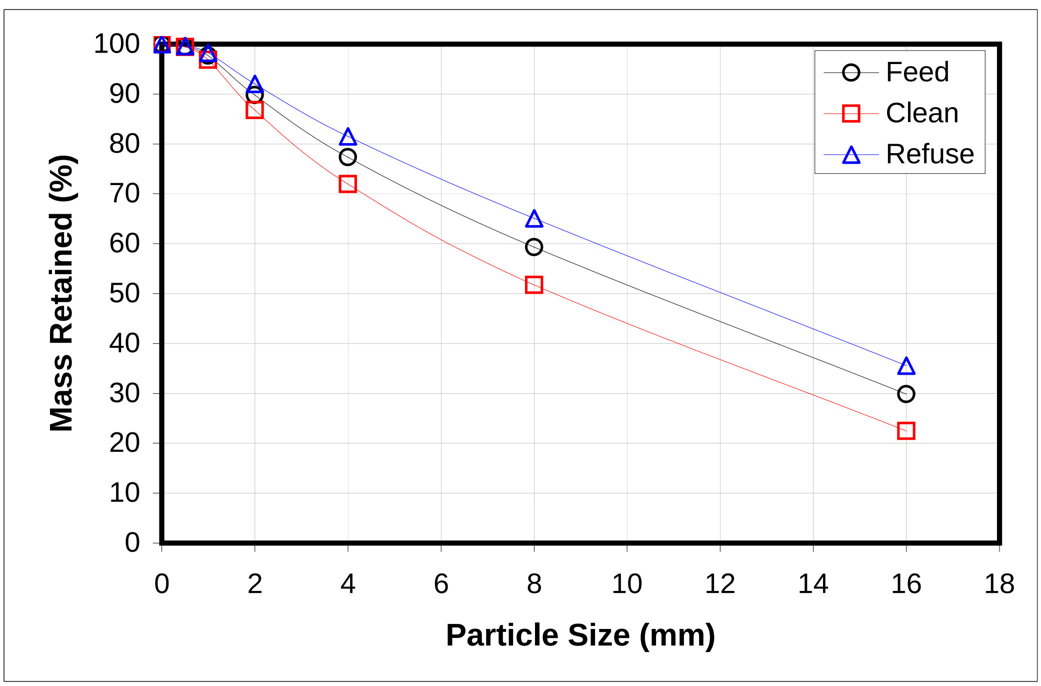
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT A1 - COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	359.3		Clean Yield (%):	43.40
Refuse Rate (t/hr):	468.6		Refuse Yield (%):	56.60
Feed Rate (t/hr):	827.9			

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	22.44	5.43	35.56	84.32	29.86	58.59
16	8	11.31	29.28	4.29	29.55	81.50	29.43	48.16
8	4	5.66	20.22	3.58	16.43	79.81	18.08	42.81
4	2	2.83	14.86	3.33	10.51	78.47	12.40	39.39
2	1	1.41	10.04	3.52	6.24	76.76	7.89	36.31
1	0.5	0.71	2.57	3.86	1.30	73.36	1.85	31.45
0.5	0.001	0.02	0.60	9.38	0.41	71.45	0.49	38.60
		Totals	100.00	4.20	100.00	81.46	100.00	47.93

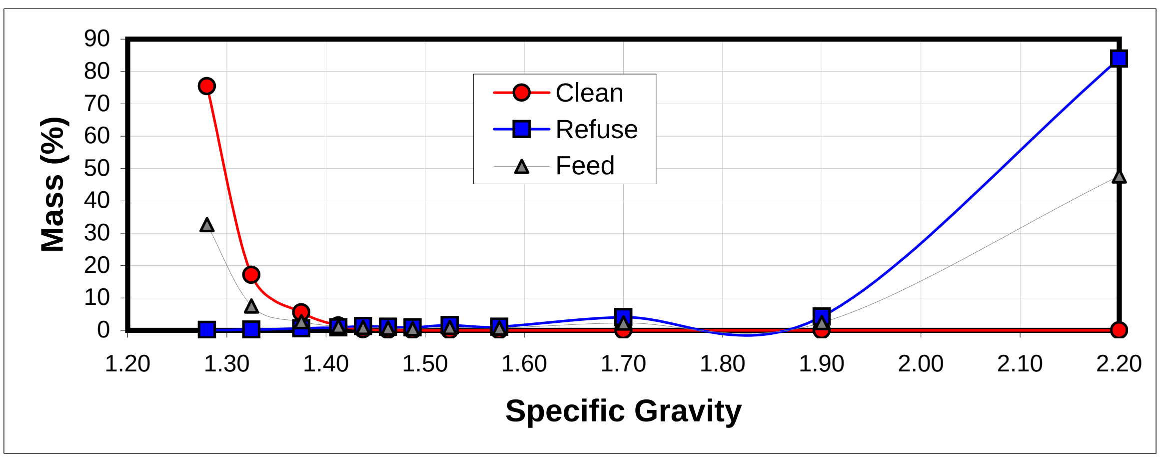
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	32.61	67.39	100.00	22.44	35.56	29.86
16	8	11.31	43.18	56.82	100.00	51.72	65.11	59.30
8	4	5.66	48.54	51.46	100.00	71.94	81.54	77.37
4	2	2.83	52.01	47.99	100.00	86.79	92.05	89.77
2	1	1.41	55.23	44.77	100.00	96.83	98.29	97.66
1	0.5	0.71	60.30	39.70	100.00	99.40	99.59	99.51
0.5	0.001	0.02	52.92	47.08	100.00	100.00	100.00	100.00
		Totals	43.40	56.60	100.00			

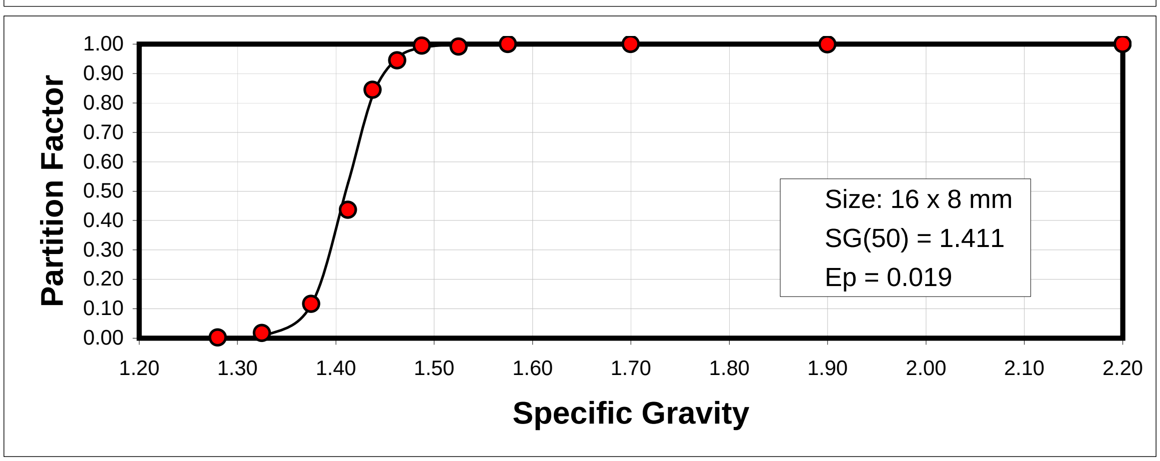


Circuit: CIRCUIT A1 - COARSE COAL HMC CIRCUIT
Size: 16 x 8 mm

Clean Yield (%)	43.18	SG Cutpoint (SG50)	1.411	Weighting (Y/N)?	Y
Refuse Yield (%)	56.82	Probable Error (Ep):	0.019	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	75.42	0.14	32.64	0.00	0.00	0.10	0.00
1.300	1.350	1.325	17.12	0.22	7.52	0.02	0.01	0.10	0.01
1.350	1.400	1.375	5.52	0.56	2.70	0.12	0.11	0.12	0.00
1.400	1.425	1.413	1.52	0.89	1.16	0.44	0.53	0.44	0.04
1.425	1.450	1.438	0.31	1.26	0.85	0.84	0.83	0.16	0.02
1.450	1.475	1.463	0.08	1.08	0.65	0.94	0.95	0.10	0.01
1.475	1.500	1.488	0.01	0.85	0.49	0.99	0.99	0.10	0.00
1.500	1.550	1.525	0.02	1.60	0.92	0.99	1.00	0.10	0.01
1.550	1.600	1.575	0.00	1.14	0.65	1.00	1.00	0.10	0.00
1.600	1.800	1.700	0.00	4.06	2.30	1.00	1.00	0.10	0.00
1.800	2.000	1.900	0.01	4.22	2.40	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.00	83.98	47.72	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.08

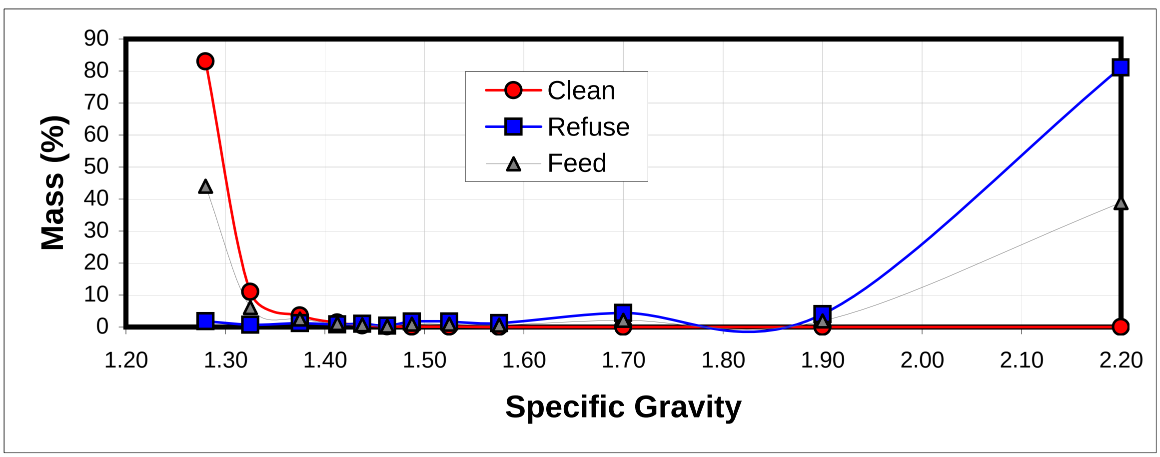


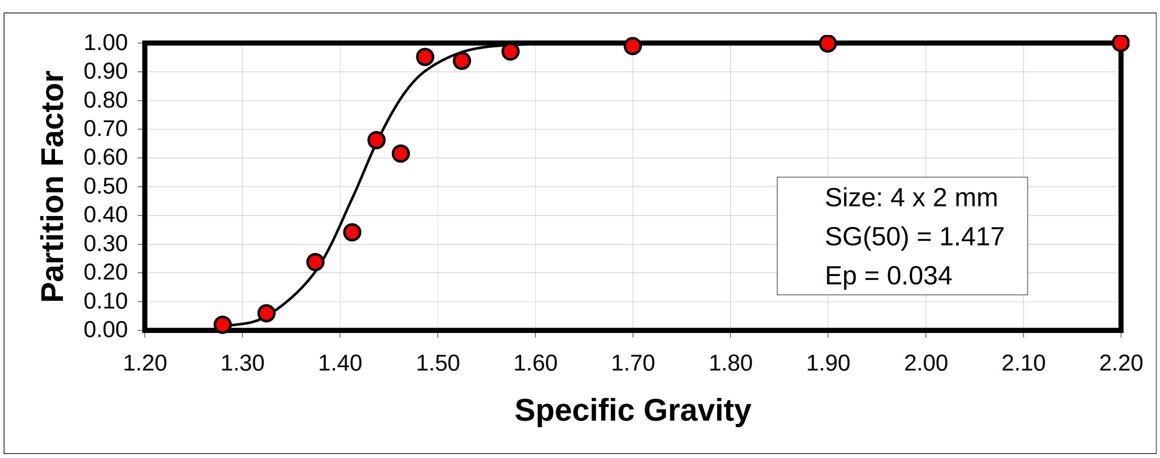


Circuit:	CIRCUIT A1 - COARSE COAL HMC CIRCUIT			
Size:	4 x 2 mm			

Clean Yield (%)	52.01	SG Cutpoint (SG50)	1.417	Weighting (Y/N)?	Y
Refuse Yield (%)	47.99	Probable Error (Ep):	0.034	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	83.04	1.78	44.04	0.02	0.01	0.10	0.01
1.300	1.350	1.325	10.99	0.74	6.07	0.06	0.05	0.10	0.01
1.350	1.400	1.375	3.60	1.21	2.45	0.24	0.21	0.24	0.02
1.400	1.425	1.413	1.35	0.76	1.07	0.34	0.46	0.34	0.13
1.425	1.450	1.438	0.48	1.01	0.73	0.66	0.66	0.34	0.00
1.450	1.475	1.463	0.23	0.39	0.31	0.61	0.81	0.39	0.25
1.475	1.500	1.488	0.08	1.73	0.87	0.95	0.90	0.10	0.23
1.500	1.550	1.525	0.10	1.68	0.86	0.94	0.97	0.10	0.09
1.550	1.600	1.575	0.04	1.23	0.61	0.97	0.99	0.10	0.06
1.600	1.800	1.700	0.05	4.35	2.11	0.99	1.00	0.10	0.01
1.800	2.000	1.900	0.01	4.04	1.94	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.04	81.07	38.93	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.80

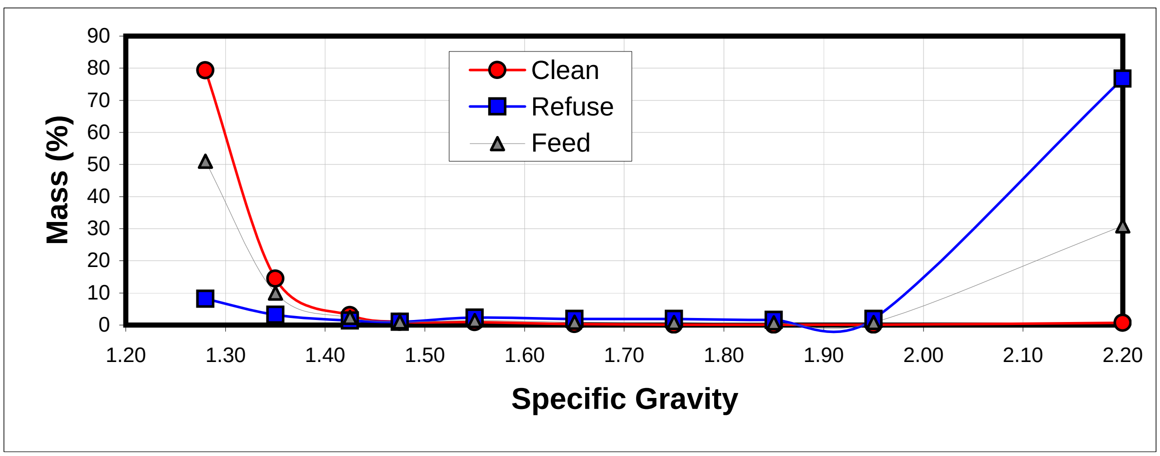


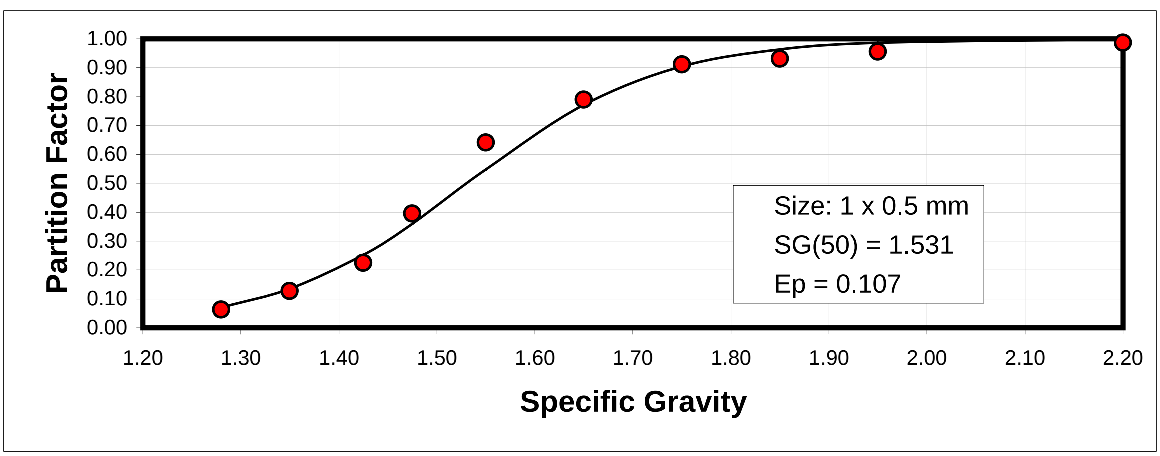


Circuit: CIRCUIT A1 - COARSE COAL HMC CIRCUIT
Size: 1 x 0.5 mm

Clean Yield (%)	60.30	SG Cutpoint (SG50)	1.531	Weighting (Y/N)?	Y
Refuse Yield (%)	39.70	Probable Error (Ep):	0.107	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	79.32	8.17	51.07	0.06	0.07	0.10	0.01
1.300	1.400	1.350	14.49	3.21	10.01	0.13	0.13	0.13	0.00
1.400	1.450	1.425	3.11	1.37	2.42	0.22	0.25	0.22	0.01
1.450	1.500	1.475	0.98	0.97	0.97	0.39	0.36	0.39	0.01
1.500	1.600	1.550	0.86	2.32	1.44	0.64	0.55	0.36	0.07
1.600	1.700	1.650	0.33	1.86	0.93	0.79	0.77	0.21	0.01
1.700	1.800	1.750	0.12	1.86	0.81	0.91	0.90	0.10	0.01
1.800	1.900	1.850	0.08	1.62	0.69	0.93	0.96	0.10	0.11
1.900	2.000	1.950	0.06	1.93	0.80	0.96	0.99	0.10	0.10
2.000	2.400	2.200	0.67	76.70	30.85	0.99	1.00	0.10	0.01
		Totals	100.00	100.00	100.00			WSSQ:	0.33

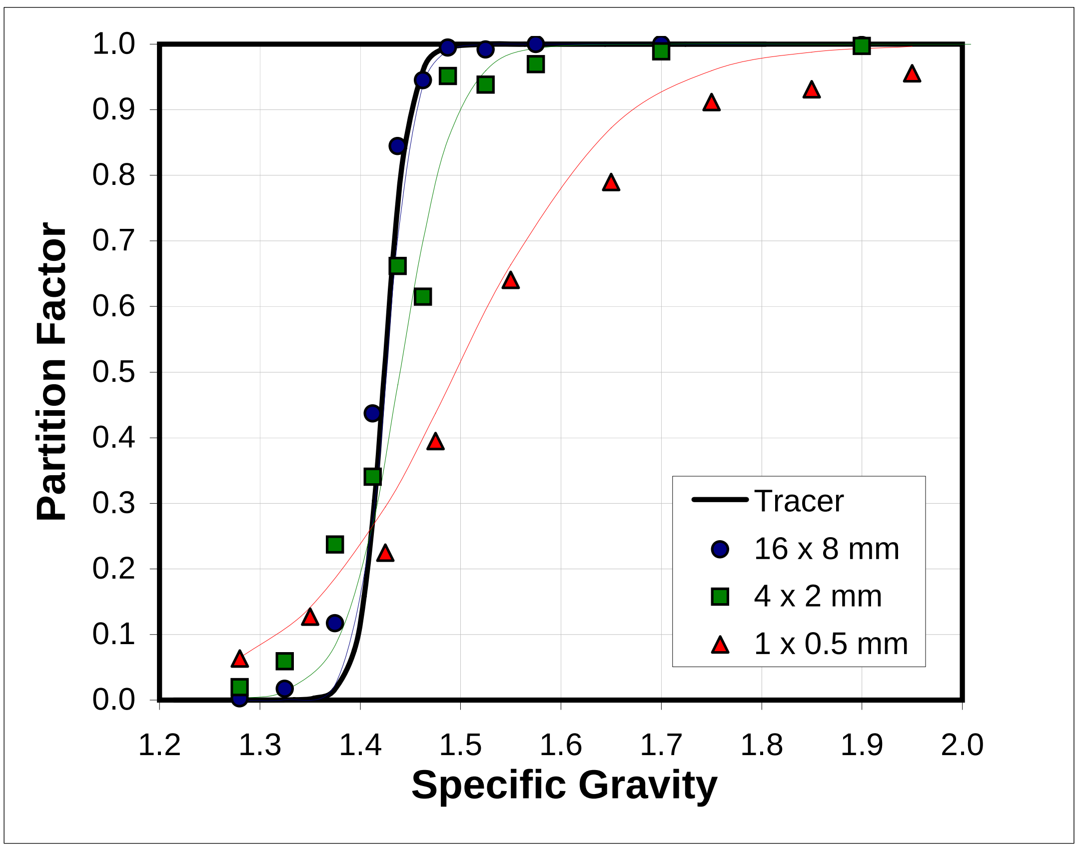


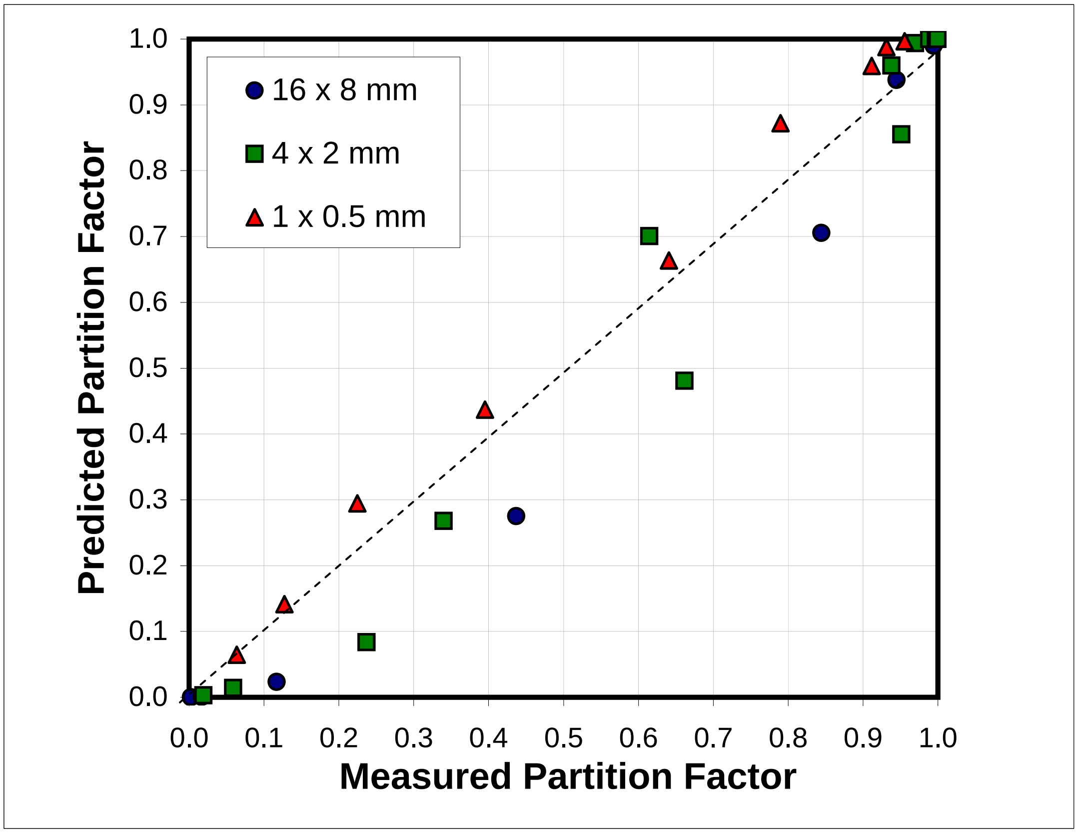


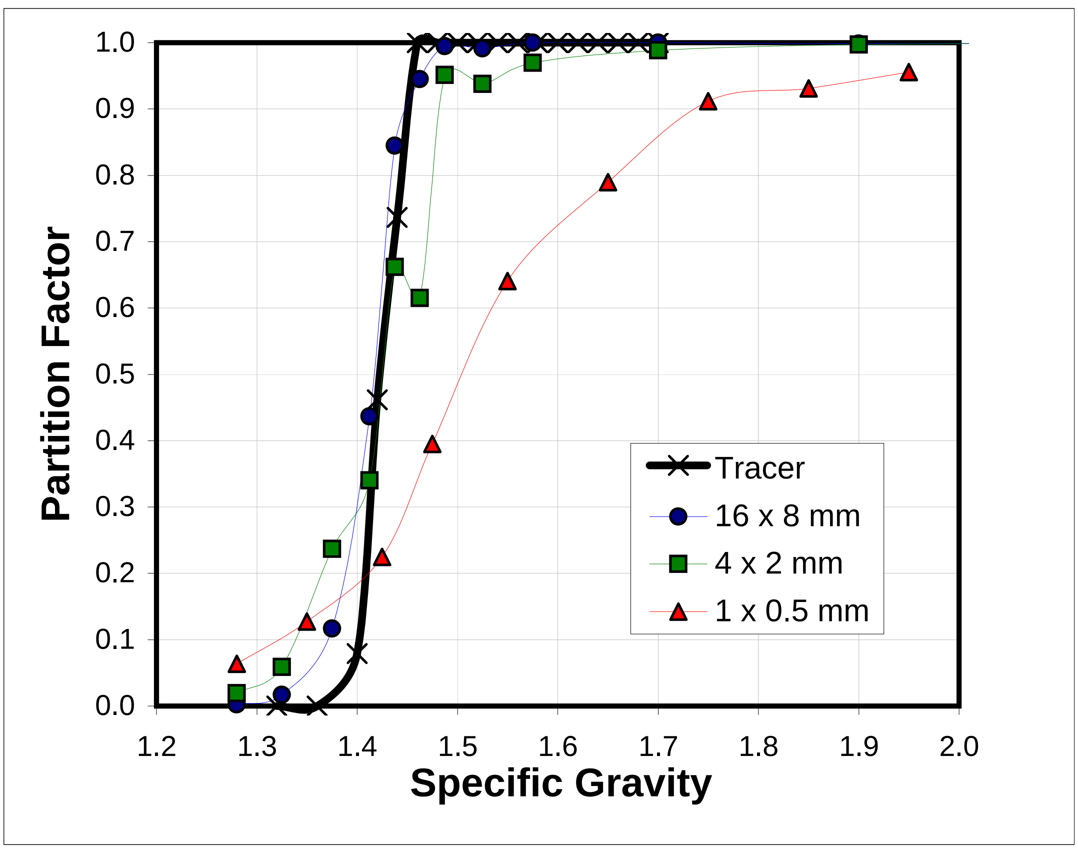
Circuit: CIRCUIT A1 - COARSE COAL HMC CIRCUIT

	Measured 16 x 8 mm	Predicted 16 x 8 mm		Measured 4 x 2 mm	Predicted 4 x 2 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.411	1.426	SG(50):	1.417	1.440	SG(50):	1.531	1.495
Ep:	0.019	0.015	Ep:	0.034	0.030	Ep:	0.107	0.088
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16 x 8 mm	Predicted 16 x 8 mm	SG	Measured 4 x 2 mm	Predicted 4 x 2 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.28	0.00	0.000	1.28	0.02	0.003	1.28	0.06	0.065
1.33	0.02	0.001	1.33	0.06	0.014	1.35	0.13	0.141
1.38	0.12	0.023	1.38	0.24	0.084	1.43	0.22	0.295
1.41	0.44	0.275	1.41	0.34	0.268	1.48	0.39	0.437
1.44	0.84	0.705	1.44	0.66	0.481	1.55	0.64	0.663
1.46	0.94	0.938	1.46	0.61	0.701	1.65	0.79	0.872
1.49	0.99	0.990	1.49	0.95	0.855	1.75	0.91	0.959
1.53	0.99	0.999	1.53	0.94	0.960	1.85	0.93	0.988
1.58	1.00	1.000	1.58	0.97	0.993	1.95	0.96	0.996
1.70	1.00	1.000	1.70	0.99	1.000			
1.90	1.00	1.000	1.90	1.00	1.000			
2.20	1.00	1.000	2.20	1.00	1.000			




Predicted Partition Factor
Measured Partition Factor
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


Partition Factor
Specific Gravity
Tracer
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0

PLANT A - HMC PERFORMANCE TEST

"COARSE CIRCUIT" - SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
CLEAN COAL	#1	1 OF 1	14,995.7	1,030.7	12,933.9	13,965.0	11,903.2	14.76%
CLEAN COAL	#2	1 OF 1	15,523.5	1,033.5	13,826.6	14,490.0	12,793.1	11.71%
CLEAN COAL	#3	1 OF 1	15,113.6	1,028.4	12,854.5	14,085.2	11,826.1	16.04%
CLEAN COAL	#4	1 OF 1	9,828.9	1,023.8	8,798.4	8,805.1	7,774.6	11.70%
CLEAN COAL	#5	1 OF 2	16,491.2	1,027.5	14,709.3	15,463.7	13,681.8	11.52%
CLEAN COAL	#5	2 of 2	4,180.3	1,031.9	3,892.1	3,148.4	2,860.2	9.15%
SUBTOTAL	#5	2	20,671.5	2,059.4	18,601.4	18,612.1	16,542.0	11.12%
TOTAL CLEAN	#5	6	76,133.2	6,175.8	67,014.8	69,957.4	60,839.0	13.03%
REFUSE	#1	1 OF 2	22,118.7	1,028.1	20,761.5	21,090.6	19,733.4	6.44%
REFUSE	#1	2 OF 2	11,169.0	1,031.5	10,532.7	10,137.5	9,501.2	6.28%
SUBTOTAL	#1	2	33,287.7	2,059.6	31,294.2	31,228.1	29,234.6	6.38%
REFUSE	#2	1 OF 2	27,052.5	1,026.8	25,456.0	26,025.7	24,429.2	6.13%
REFUSE	#2	2 OF 2	13,247.8	1,028.3	12,491.8	12,219.5	11,463.5	6.19%
SUBTOTAL	#2	2	40,300.3	2,055.1	37,947.8	38,245.2	35,892.7	6.15%
REFUSE	#3	1 OF 1	24,661.0	1,028.5	22,885.3	23,632.5	21,856.8	7.51%
REFUSE	#4	1 OF 1	20,464.9	1,030.2	19,011.7	19,434.7	17,981.5	7.48%
TOTAL REFUSE		6	118,713.9	6,173.4	111,139.0	112,540.5	104,965.6	6.73%

PLANT A - HMC PERFORMANCE TEST

"FINE CIRCUIT" - SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
FEED	1A	1 OF 2	19,466.2	1,033.1	17,482.9	18,433.1	16,449.8	10.76%
FEED	1A	2 of 2	19,813.3	1,027.6	17,777.4	18,785.7	16,749.8	10.84%
SUBTOTAL	1A	2	39,279.5	2,060.7	35,260.3	37,218.8	33,199.6	10.80%
FEED	2A	1 OF 2	22,037.8	1,031.8	20,069.6	21,006.0	19,037.8	9.37%
FEED	2A	2 of 2	21,231.7	1,030.9	19,084.1	20,200.8	18,053.2	10.63%
SUBTOTAL	2A	2	43,269.5	2,062.7	39,153.7	41,206.8	37,091.0	9.99%
TOTAL FEED	2A	4	82,549.0	4,123.4	74,414.0	78,425.6	70,290.6	10.37%
CLEAN COAL	#1	1 OF 1	14,748.8	1,035.5	12,217.0	13,713.3	11,181.5	18.46%
CLEAN COAL	#2	1 OF 1	19,016.4	1,037.0	16,080.0	17,979.4	15,043.0	16.33%
CLEAN COAL	#3	1 OF 1	15,509.5	1,039.9	12,985.0	14,469.6	11,945.1	17.45%
TOTAL CLEAN		3	49,274.7	3,112.4	41,282.0	46,162.3	38,169.6	17.31%
REFUSE	#1	1 OF 1	26,189.3	1,038.7	23,484.6	25,150.6	22,445.9	10.75%
REFUSE	#2	1 OF 1	20,796.0	1,041.2	18,556.2	19,754.8	17,515.0	11.34%
TOTAL REFUSE		2	46,985.3	2,079.9	42,040.8	44,905.4	39,960.9	11.01%

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES

FEED MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	7,678.8	TARE WT.	1,039.4
SOLIDS WT.	2,621.4	% SOLIDS	39.48%
LAB NO.	SIZE	WT (Grams)	WT %
968,288	+ 25M	66.2	2.53%
968,289	25M x 0	2,555.2	97.47%
	Totals	2,621.4	100.00%

CLEAN COAL MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,113.5	TARE WT.	1,042.3
SOLIDS WT.	1,757.7	% SOLIDS	34.66%
LAB NO.	SIZE	WT (Grams)	WT %
968,290	+ 25M	16.4	0.93%
968,291	25M x 0	1,741.3	99.07%
	Totals	1,757.7	100.00%

REFUSE MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	7,047.2	TARE WT.	1,045.2
SOLIDS WT.	2,919.5	% SOLIDS	48.64%
LAB NO.	SIZE	WT (Grams)	WT %
968,292	+ 25M	25.8	0.88%
968,293	25M x 0	2,893.7	99.12%
	Totals	2,919.5	100.00%

FEED MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,250.3	TARE WT.	1,035.8
SOLIDS WT.	1,849.2	% SOLIDS	35.46%
LAB NO.	SIZE	WT (Grams)	WT %
968,294	+ 25M	34.8	1.88%
968,295	25M x 0	1,814.4	98.12%
	Totals	1,849.2	100.00%

CLEAN COAL MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	8,294.7	TARE WT.	1,032.2
SOLIDS WT.	2,102.1	% SOLIDS	28.94%
LAB NO.	SIZE	WT (Grams)	WT %
968,296	+ 25M	43.2	2.06%
968,297	25M x 0	2,058.9	97.94%
	Totals	2,102.1	100.00%

REFUSE MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,863.5	TARE WT.	1,033.2
SOLIDS WT.	2,573.0	% SOLIDS	44.13%
LAB NO.	SIZE	WT (Grams)	WT %
968,298	+ 25M	22.4	0.87%
968,299	25M x 0	2,550.6	99.13%
	Totals	2,573.0	100.00%

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,362	**Lab #:**	970,362
Weights	Grams	**Weights**	Grams
Flask	81.7484	**Flask**	78.2091
Flask, Non-Mag, Mags	96.7836	**Flask, Non-Mag, Mags**	93.7151
Flask + Mags	91.3495	**Flask + Mags**	88.0789
% Mags:	63.86%	**% Mags:**	63.65%

RUN AVG:	**63.75%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,363	**Lab #:**	970,363
Weights	Grams	**Weights**	Grams
Flask	68.4724	**Flask**	67.1420
Flask, Non-Mag, Mags	83.7192	**Flask, Non-Mag, Mags**	82.7138
Flask + Mags	78.2137	**Flask + Mags**	77.1091
% Mags:	63.89%	**% Mags:**	64.01%

RUN AVG:	**63.95%**
TOT AVG:	**63.85%**

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 2 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,364	**Lab #:**	970,364
Weights	Grams	**Weights**	Grams
Flask	63.5954	**Flask**	68.1792
Flask, Non-Mag, Mags	78.7190	**Flask, Non-Mag, Mags**	83.7174
Flask + Mags	72.9513	**Flask + Mags**	77.8241
% Mags:	61.86%	**% Mags:**	62.07%

RUN AVG:	**61.97%**

ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,365	**Lab #:**	970,365
Weights	Grams	**Weights**	Grams
Flask	68.3089	**Flask**	63.5033
Flask, Non-Mag, Mags	83.7192	**Flask, Non-Mag, Mags**	78.7361
Flask + Mags	77.8573	**Flask + Mags**	72.9496
% Mags:	61.96%	**% Mags:**	62.01%

RUN AVG:	**61.99%**

TOT AVG:	**61.98%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 3 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,366	**Lab #:**	970,366
Weights	Grams	**Weights**	Grams
Flask	67.1996	**Flask**	64.6445
Flask, Non-Mag, Mags	82.7260	**Flask, Non-Mag, Mags**	79.7268
Flask + Mags	78.3883	**Flask + Mags**	75.4975
% Mags:	72.06%	**% Mags:**	71.96%

RUN AVG:	**72.01%**

ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,367	**Lab #:**	970,367
Weights	Grams	**Weights**	Grams
Flask	67.4823	**Flask**	66.3560
Flask, Non-Mag, Mags	82.7127	**Flask, Non-Mag, Mags**	81.7193
Flask + Mags	78.4701	**Flask + Mags**	77.3751
% Mags:	72.14%	**% Mags:**	71.72%

RUN AVG:	**71.93%**

TOT AVG:	**71.97%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 4 of 6

Plant:	**PLANT A**		
Circuit:	**FINE CIRCUIT**		
ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,368	**Lab #:**	970,368
Weights	Grams	**Weights**	Grams
Flask	68.4161	**Flask**	67.0943
Flask, Non-Mag, Mags	83.7484	**Flask, Non-Mag, Mags**	82.7299
Flask + Mags	79.5999	**Flask + Mags**	78.4912
% Mags:	72.94%	**% Mags:**	72.89%

RUN AVG:	**72.92%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,369	**Lab #:**	970,369
Weights	Grams	**Weights**	Grams
Flask	67.3710	**Flask**	63.8125
Flask, Non-Mag, Mags	82.7308	**Flask, Non-Mag, Mags**	78.7282
Flask + Mags	78.6380	**Flask + Mags**	74.6836
% Mags:	73.35%	**% Mags:**	72.88%

RUN AVG:	**73.12%**

TOT AVG:	**73.02%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 5 of 6

Plant:	**PLANT A**		
Circuit:	**FINE CIRCUIT**		
ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,370	**Lab #:**	970,370
Weights	Grams	**Weights**	Grams
Flask	68.0970	**Flask**	68.0074
Flask, Non-Mag, Mags	83.7119	**Flask, Non-Mag, Mags**	83.7124
Flask + Mags	78.7294	**Flask + Mags**	78.6975
% Mags:	68.09%	**% Mags:**	68.07%

RUN AVG:	**68.08%**

ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,371	**Lab #:**	970,371
Weights	Grams	**Weights**	Grams
Flask	67.7099	**Flask**	63.7018
Flask, Non-Mag, Mags	82.7330	**Flask, Non-Mag, Mags**	78.7448
Flask + Mags	77.9399	**Flask + Mags**	73.9186
% Mags:	68.10%	**% Mags:**	67.92%

RUN AVG:	**68.01%**

TOT AVG:	**68.04%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 6 of 6

Plant:	**PLANT A**		
Circuit:	**FINE CIRCUIT**		
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,372	**Lab #:**	970,372
Weights	Grams	**Weights**	Grams
Flask	65.2331	**Flask**	68.7366
Flask, Non-Mag, Mags	80.7953	**Flask, Non-Mag, Mags**	83.7987
Flask + Mags	78.3798	**Flask + Mags**	81.4530
% Mags:	84.48%	**% Mags:**	84.43%

RUN AVG:	**84.45%**

ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,373	**Lab #:**	970,373
Weights	Grams	**Weights**	Grams
Flask	64.7025	**Flask**	68.6499
Flask, Non-Mag, Mags	79.7612	**Flask, Non-Mag, Mags**	83.7198
Flask + Mags	77.3727	**Flask + Mags**	81.3507
% Mags:	84.14%	**% Mags:**	84.28%

RUN AVG:	**84.21%**
TOT AVG:	**84.33%**

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all three (6) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	60,839.0	Grams or	134.127	Lbs
START WEIGHT - REWEIGH:	134.4	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
969,895	4.20

Screen Analysis (Using 7 Containers) 117.6 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
969,896	+ 16mm	11,940.6	Grams	22.44%	5.43
969,897	*16 x 8mm*	15,581.2	Grams	29.28%	4.29
969,898	8 x 4mm	10,757.2	Grams	20.22%	3.58
Totals	**+4mm**	**38,279.0**	**Grams**	**71.94%**	**4.45**

Total +4mm Wt	38,279.0	Grams	71.94%			
Total -4mm Wt	14,932.9	Grams	28.06%			
Total Wt	53,211.9	Grams	100.00%	or	117.3	Lbs
Screen Loss	130.6	Grams		or	0.24	%
-4mm Split Wt	14,932.9	Grams	(Use All)			
Screen Loss	103.2	Grams		or	0.69	%
Total Scr Loss	233.8	Grams		or	0.44	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
969,899	*4 x 2mm*	7,851.4	Grams	14.86%	3.33
969,900	2 x 1mm	5,303.1	Grams	10.04%	3.52
969,901	*1 x 0.5mm*	1,357.2	Grams	2.57%	3.86
969,902	0.5mm x 0	318.0	Grams	0.60%	9.38
Totals	**4mm x 0**	**14,829.7**	**Grams**	**28.06%**	**3.58**

Totals	**+16mm x 0**	**53,108.7**	**Grams**	**100.00%**	**4.20**

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	11,685.3	Grams			
LOSS:	48.8	Grams	or	0.42	%

LAB #	GRAVITY	WT	Units	WT%
970,378	1.300	8,776.5	Grams	75.42%
970,379	1.350	1,992.6	Grams	17.12%
970,380	1.400	642.0	Grams	5.52%
970,381	1.425	176.5	Grams	1.52%
970,382	1.450	35.5	Grams	0.31%
970,383	1.475	9.7	Grams	0.08%
970,384	1.500	0.7	Grams	0.01%
970,385	1.550	2.1	Grams	0.02%
	1.600	0.0	Grams	0.00%
	1.800	0.0	Grams	0.00%
970,386	2.000	0.9	Grams	0.01%
	SINK	0.0	Grams	0.00%
TOTAL		11,636.5	Grams	100.00%

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	5,888.6	Grams			
LOSS:	25.9	Grams	or	0.44	%

LAB #	GRAVITY	WT	Units	WT%
970,387	1.300	4,868.4	Grams	83.04%
970,388	1.350	644.2	Grams	10.99%
970,389	1.400	210.9	Grams	3.60%
970,390	1.425	79.4	Grams	1.35%
970,391	1.450	27.9	Grams	0.48%
970,392	1.475	13.3	Grams	0.23%
970,393	1.500	4.8	Grams	0.08%
970,394	1.550	6.0	Grams	0.10%
970,395	1.600	2.1	Grams	0.04%
970,396	1.800	2.7	Grams	0.05%
970,397	2.000	0.6	Grams	0.01%
970,398	SINK	2.4	Grams	0.04%
TOTAL		5,862.7	Grams	100.00%

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm			
START WT:	1,016.3	Grams		
LOSS:	3.0	Grams	or	0.30 %

LAB #	GRAVITY	WT	Units	WT%
971,421	1.300	803.7	Grams	79.32%
971,422	1.400	146.8	Grams	14.49%
971,423	1.450	31.5	Grams	3.11%
971,424	1.500	9.9	Grams	0.98%
971,425	1.600	8.7	Grams	0.86%
971,426	1.700	3.3	Grams	0.33%
971,427	1.800	1.2	Grams	0.12%
971,428	1.900	0.8	Grams	0.08%
971,429	2.000	0.6	Grams	0.06%
971,430	SINK	6.8	Grams	0.67%
TOTAL		1,013.3	Grams	100.00%

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all three (6) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	104,965.6	Grams or	231.410	Lbs
START WEIGHT - REWEIGH:	231.4	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
972,213	81.18

Screen Analysis (Using 7 Containers) 201.1 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
972,214	+ 16mm	32,386.1	Grams	35.56%	84.32
972,215	*16 x 8mm*	26,917.8	Grams	29.55%	81.50
972,216	8 x 4mm	14,970.0	Grams	16.43%	79.81
Totals	**+4mm**	**74,273.9**	**Grams**	**81.54%**	**82.39**

Total +4mm Wt	74,273.9	Grams	81.54%			
Total -4mm Wt	16,813.0	Grams	18.46%			
Total Wt	91,086.9	Grams	100.00%	or	200.8	Lbs
Screen Loss	130.5	Grams		or	0.14	%
-4mm Split Wt	16,813.0	Grams	(Use All)			
Screen Loss	130.2	Grams		or	0.77	%
Total Scr Loss	260.7	Grams		or	0.29	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
972,217	*4 x 2mm*	9,501.9	Grams	10.51%	78.47
972,218	2 x 1mm	5,637.7	Grams	6.24%	76.76
972,219	*1 x 0.5mm*	1,172.1	Grams	1.30%	73.36
972,220	0.5mm x 0	371.1	Grams	0.41%	71.45
Totals	**4mm x 0**	**16,682.8**	**Grams**	**18.46%**	**77.38**

Totals	**+16mm x 0**	**90,956.7**	**Grams**	**100.00%**	**81.46**

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

PAGE 1 OF 3

SIZE:	16 x 8mm				
START WT:	20,028.7	Grams			
LOSS:	59.4	Grams	or	0.30	%

LAB #	GRAVITY	WT	Units	WT%
972,221	1.300	27.2	Grams	0.14%
972,222	1.350	44.9	Grams	0.22%
972,223	1.400	110.9	Grams	0.56%
972,224	1.425	178.5	Grams	0.89%
972,225	1.450	251.6	Grams	1.26%
972,226	1.475	216.4	Grams	1.08%
972,227	1.500	169.6	Grams	0.85%
972,228	1.550	319.7	Grams	1.60%
972,229	1.600	227.3	Grams	1.14%
972,230	1.800	810.0	Grams	4.06%
972,231	2.000	842.7	Grams	4.22%
972,232	SINK	16,770.5	Grams	83.98%
TOTAL		19,969.3	Grams	100.00%

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	7,113.3	Grams			
LOSS:	5.6	Grams	or	0.08	%

LAB #	GRAVITY	WT	Units	WT%
975,254	1.300	126.6	Grams	1.78%
975,255	1.350	52.9	Grams	0.74%
975,256	1.400	86.1	Grams	1.21%
975,257	1.425	53.8	Grams	0.76%
975,258	1.450	71.7	Grams	1.01%
975,259	1.475	27.9	Grams	0.39%
975,260	1.500	123.1	Grams	1.73%
975,261	1.550	119.3	Grams	1.68%
975,262	1.600	87.6	Grams	1.23%
975,263	1.800	309.4	Grams	4.35%
975,264	2.000	286.9	Grams	4.04%
975,265	SINK	5,762.4	Grams	81.07%
TOTAL		7,107.7	Grams	100.00%

CIRCUIT A1 - HMC PERFORMANCE TEST

COARSE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	879.5	Grams			
LOSS:	2.0	Grams	or	0.23	%

LAB #	GRAVITY	WT	Units	WT%
976,472	1.300	71.7	Grams	8.17%
976,473	1.400	28.2	Grams	3.21%
976,474	1.450	12.0	Grams	1.37%
976,475	1.500	8.5	Grams	0.97%
976,476	1.600	20.4	Grams	2.32%
976,477	1.700	16.3	Grams	1.86%
976,478	1.800	16.3	Grams	1.86%
976,479	1.900	14.2	Grams	1.62%
976,480	2.000	16.9	Grams	1.93%
976,481	SINK	673.0	Grams	76.70%
TOTAL		877.5	Grams	100.00%

Test Description: CIRCUIT A2 - FINE COAL HMC CIRCUIT

Feed Coal Type: 70% White Kn (P), 30% Hernshaw

	Body	Vortex	Apex
Manufacturer:	Krebs	Krebs	Krebs
Diameter (Inch):	30	14	1.52-11.6
Wear Condition:	Good	Good	Fair
Part Alignment:			Fair

Plant Feed Rate (tph):	2130		Tracer Size (mm):	16
Circuit Feed Rate(tph):	453		Tracer Shape:	Cubes
Inlet Pressure (psi):	0	No gauge	Weighting (Y/N)?	N
Gauge Position (inch):	-33		SG Cutpoint (SG50):	1.380
Head (Diameters):	-1.1	LOW!	Probable Error (Ep):	0.005
Magnetite Grade:	B		Low SG Offset:	0.000

Tracer SG	Tracer in Feed	Overflow (Clean Coal) A	B	C	D	E	F	Sum	Underflow (Refuse) A	B	C	D	E	F	Sum	Tracers Collected	Tracers Lost	Refuse Partition	Fitted Partition	Weight Factor	Weighted Error
1.32	10	2	3	0				5	0	0	0	0			0	0.50	0.50	0.00	0.00	0.10	0.00
1.36	10	0	4	2				6	0	0	0	0			0	0.60	0.40	0.00	0.01	0.10	0.00
1.40	10	0	0	0				0	1	6	0	1			8	0.80	0.20	1.00	0.99	0.10	0.00
1.42	10	0	0	0				0	3	4	1	0			8	0.80	0.20	1.00	1.00	0.10	0.00
1.44	10	0	0	0				0	2	1	1	3			7	0.70	0.30	1.00	1.00	0.10	0.00
1.46	10	0	0	0				0	6	2	0	1			9	0.90	0.10	1.00	1.00	0.10	0.00
1.48	10	0	0	0				0	3	5	1	1			10	1.00	0.00	1.00	1.00	0.10	0.00
Known Dropped		0	0	0				0	0	0	0	0			0					Total WSSQ:	0.00

Description: CIRCUIT A2 - FINE COAL HMC CIRCUIT

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections Real World	O&M Factors	Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1	0	0.002
16	8	11.31	0.003	1.5	1	0	0.005
8	4	5.66	0.007	1.5	1	0	0.010
4	2	2.83	0.013	1.5	1	0	0.020
2	1	1.41	0.026	1.5	1	0	0.039
1	0.5	0.71	0.052	1.5	1	0	0.078

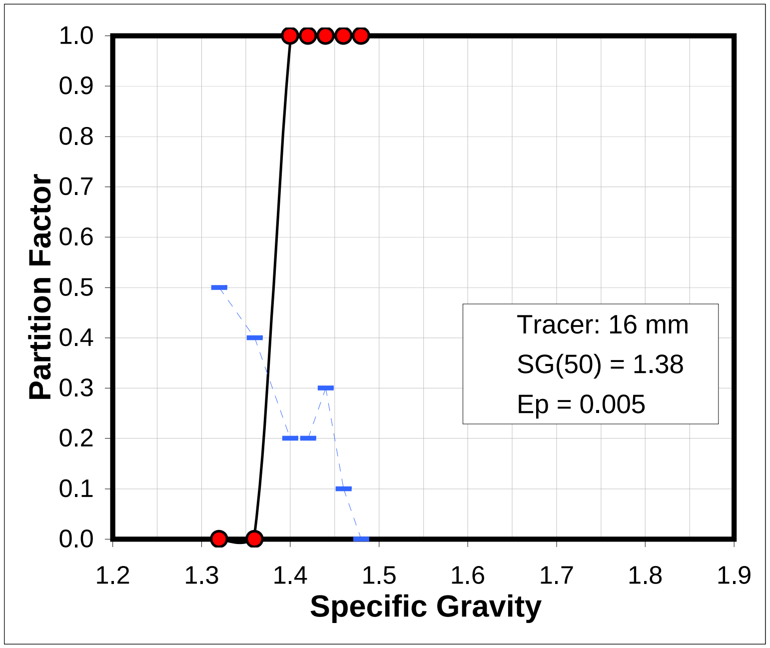
Comments:

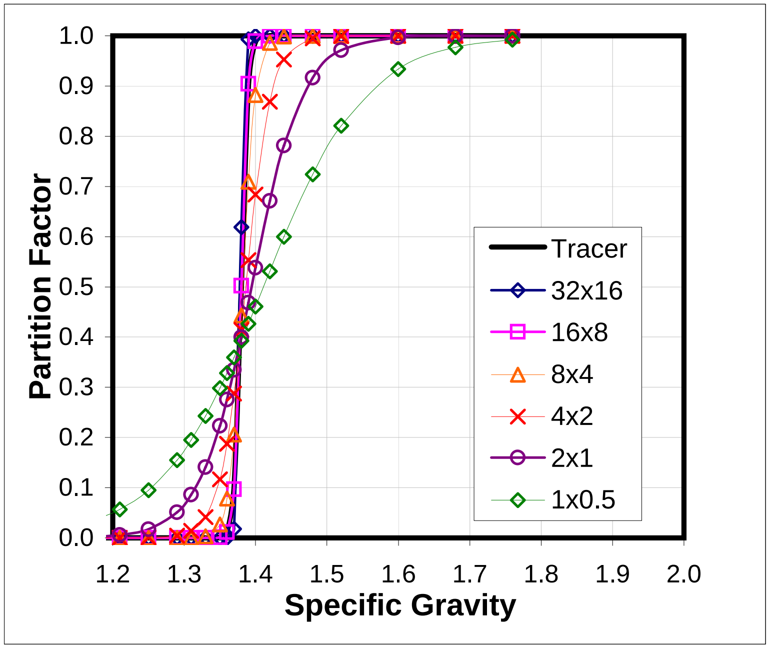
	SG	Split
O/F:	1.323	0.614
U/F:	1.600	0.386
Feed:	1.430	1.000

	SG	Split
Pivot:	1.378	0.386
O/F-U/F	0.28	

Obs.	Marcy Scale SG Feed	O/F	U/F
1	1.43	1.33	1.59
2		1.32	1.61
3		1.32	
4			
5			
Avg.	1.430	1.323	1.600

Size	16	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.380	1.379	1.380	1.382	1.386	1.395	1.411
Ep	0.005	0.002	0.005	0.010	0.020	0.039	0.08
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





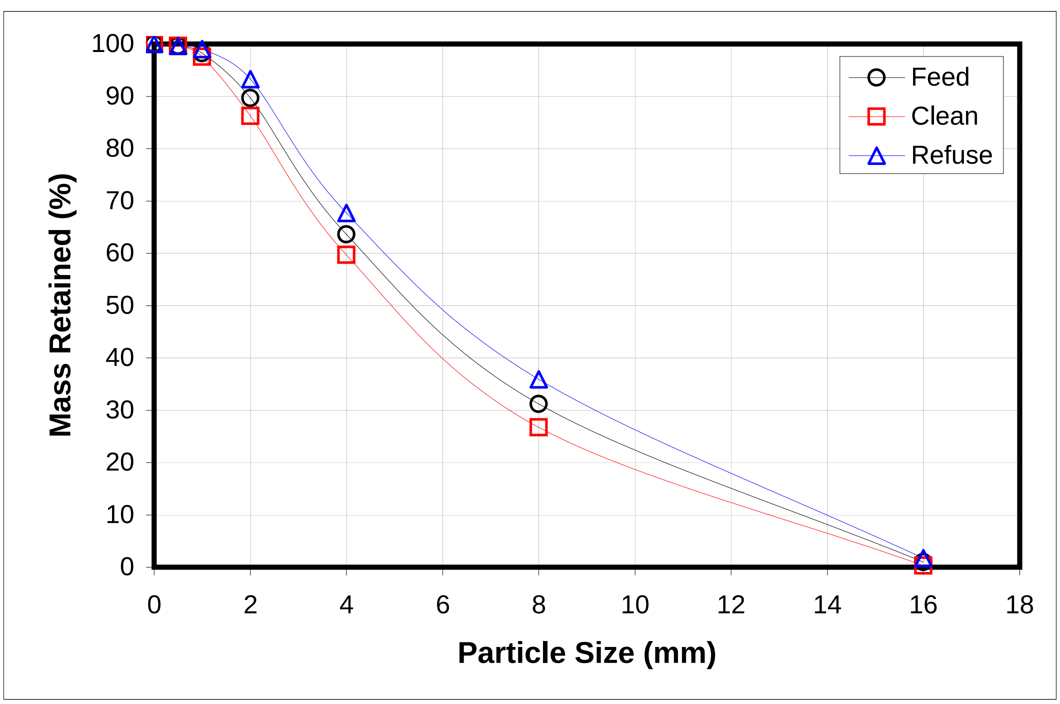
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT A2 - FINE COAL HMC CIRCUIT

Clean Rate (t/hr):	233.0		Clean Yield (%):	51.44
Refuse Rate (t/hr):	220.0		Refuse Yield (%):	48.56
Feed Rate (t/hr):	453.0			

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	0.32	6.38	1.73	86.35	1.01	73.14
16	8	11.31	26.38	4.09	34.19	78.45	30.17	45.01
8	4	5.66	33.02	3.52	31.77	76.97	32.41	38.48
4	2	2.83	26.53	3.20	25.55	75.16	26.05	37.46
2	1	1.41	11.30	3.16	5.75	73.60	8.61	26.01
1	0.5	0.71	2.07	3.34	0.62	67.82	1.37	17.54
0.5	0.001	0.02	0.37	16.16	0.39	66.99	0.38	41.37
		Totals	100.00	3.60	100.00	76.89	100.00	39.18

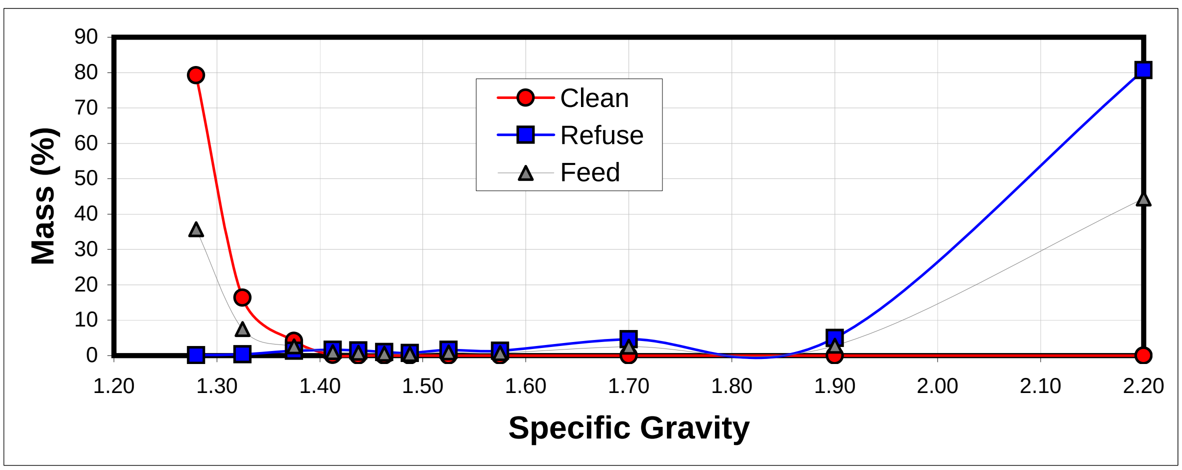
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	16.52	83.48	100.00	0.32	1.73	1.01
16	8	11.31	44.97	55.03	100.00	26.70	35.93	31.18
8	4	5.66	52.41	47.59	100.00	59.72	67.70	63.59
4	2	2.83	52.39	47.61	100.00	86.25	93.24	89.65
2	1	1.41	67.57	32.43	100.00	97.56	98.99	98.25
1	0.5	0.71	77.98	22.02	100.00	99.63	99.61	99.62
0.5	0.001	0.02	50.40	49.60	100.00	100.00	100.00	100.00
		Totals	51.44	48.56	100.00			

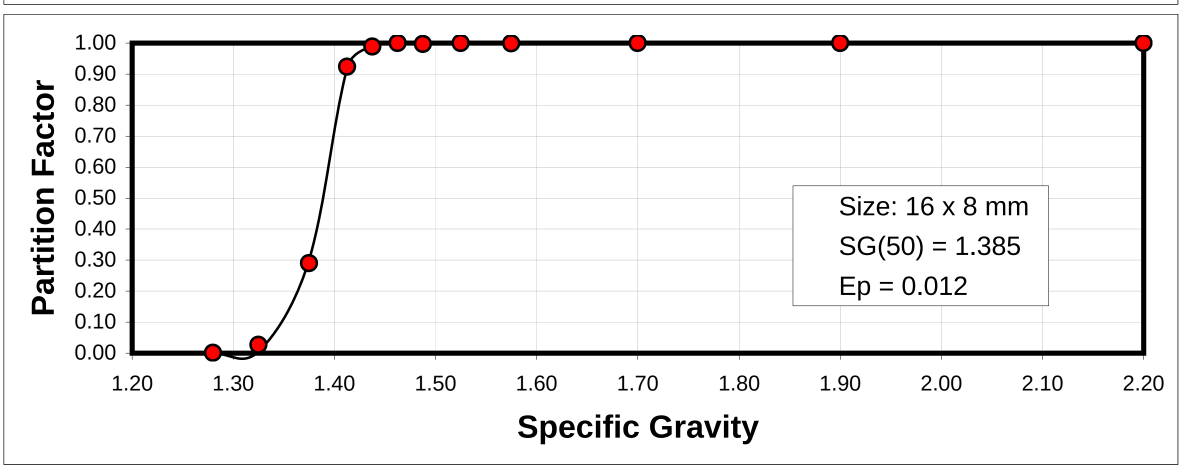


Circuit:	CIRCUIT A2 - FINE COAL HMC CIRCUIT
Size:	16 x 8 mm

Clean Yield (%)	44.97	SG Cutpoint (SG50)	1.385	Weighting (Y/N)?	Y
Refuse Yield (%)	55.03	Probable Error (Ep):	0.012	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	79.27	0.09	35.70	0.00	0.00	0.10	0.00
1.300	1.350	1.325	16.34	0.37	7.55	0.03	0.01	0.10	0.05
1.350	1.400	1.375	4.20	1.40	2.66	0.29	0.30	0.29	0.00
1.400	1.425	1.413	0.17	1.66	0.99	0.92	0.92	0.10	0.00
1.425	1.450	1.438	0.02	1.46	0.81	0.99	0.99	0.10	0.00
1.450	1.475	1.463	0.00	1.02	0.56	1.00	1.00	0.10	0.00
1.475	1.500	1.488	0.00	0.74	0.41	1.00	1.00	0.10	0.00
1.500	1.550	1.525	0.00	1.67	0.92	1.00	1.00	0.10	0.00
1.550	1.600	1.575	0.00	1.35	0.75	1.00	1.00	0.10	0.00
1.600	1.800	1.700	0.00	4.58	2.52	1.00	1.00	0.10	0.00
1.800	2.000	1.900	0.00	5.02	2.76	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.00	80.65	44.38	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.05

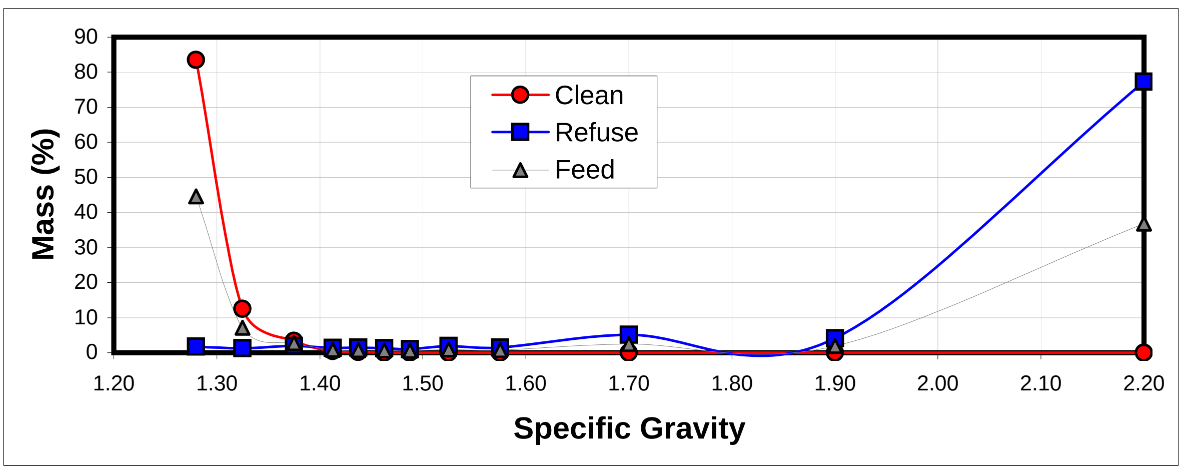


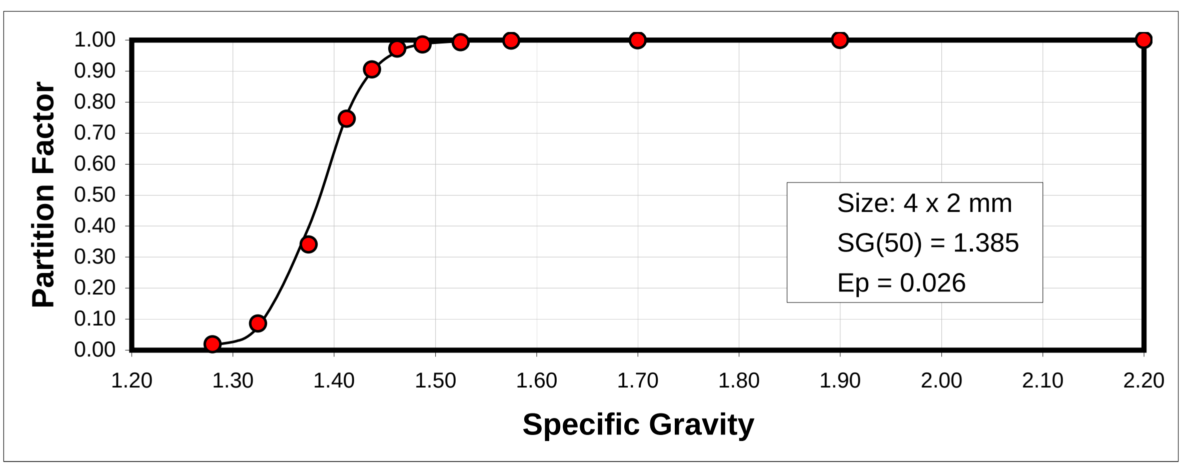


Circuit:	CIRCUIT A2 - FINE COAL HMC CIRCUIT
Size:	4 x 2 mm

Clean Yield (%)	52.39	SG Cutpoint (SG50)	1.385	Weighting (Y/N)?	Y
Refuse Yield (%)	47.61	Probable Error (Ep):	0.026	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	83.48	1.75	44.57	0.02	0.01	0.10	0.00
1.300	1.350	1.325	12.50	1.28	7.16	0.09	0.08	0.10	0.01
1.350	1.400	1.375	3.39	1.93	2.70	0.34	0.40	0.34	0.03
1.400	1.425	1.413	0.42	1.35	0.86	0.75	0.76	0.25	0.00
1.425	1.450	1.438	0.14	1.44	0.76	0.91	0.90	0.10	0.00
1.450	1.475	1.463	0.03	1.25	0.61	0.97	0.96	0.10	0.01
1.475	1.500	1.488	0.01	1.04	0.50	0.99	0.99	0.10	0.00
1.500	1.550	1.525	0.01	1.94	0.93	0.99	1.00	0.10	0.00
1.550	1.600	1.575	0.00	1.46	0.70	1.00	1.00	0.10	0.00
1.600	1.800	1.700	0.00	5.12	2.44	1.00	1.00	0.10	0.00
1.800	2.000	1.900	0.00	4.08	1.95	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.00	77.34	36.83	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.06

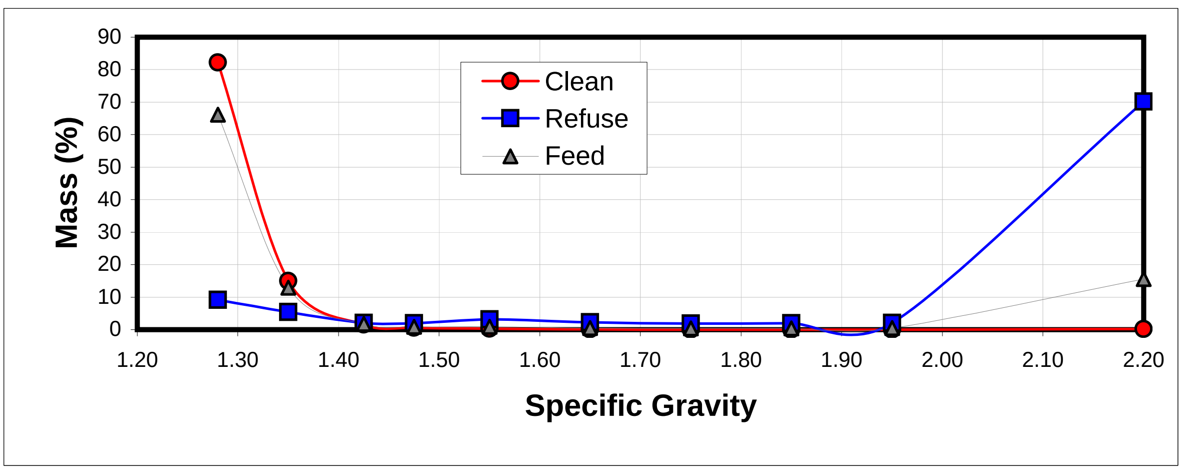


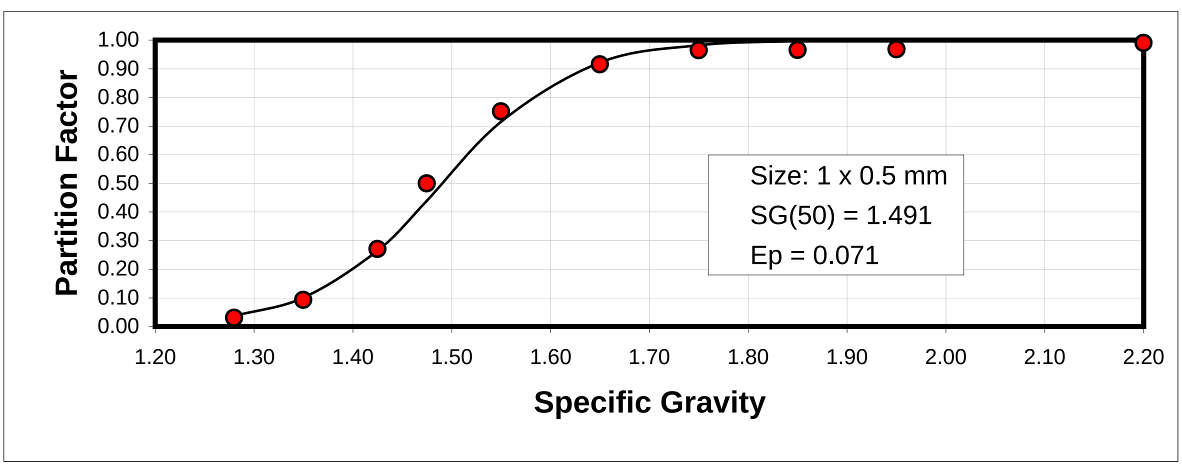


Circuit: CIRCUIT A2 - FINE COAL HMC CIRCUIT
Size: 1 x 0.5 mm

Clean Yield (%)	77.98	SG Cutpoint (SG50)	1.491	Weighting (Y/N)?	Y
Refuse Yield (%)	22.02	Probable Error (Ep):	0.071	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	82.21	9.15	66.12	0.03	0.04	0.10	0.00
1.300	1.400	1.350	15.03	5.41	12.91	0.09	0.10	0.10	0.01
1.400	1.450	1.425	1.62	2.12	1.73	0.27	0.26	0.27	0.00
1.450	1.500	1.475	0.54	1.93	0.85	0.50	0.44	0.50	0.01
1.500	1.600	1.550	0.29	3.11	0.91	0.75	0.71	0.25	0.02
1.600	1.700	1.650	0.06	2.24	0.54	0.92	0.92	0.10	0.00
1.700	1.800	1.750	0.02	1.87	0.43	0.96	0.98	0.10	0.03
1.800	1.900	1.850	0.02	1.93	0.44	0.97	1.00	0.10	0.09
1.900	2.000	1.950	0.02	2.05	0.47	0.97	1.00	0.10	0.10
2.000	2.400	2.200	0.19	70.19	15.61	0.99	1.00	0.10	0.01
		Totals	100.00	100.00	100.00			WSSQ:	0.29

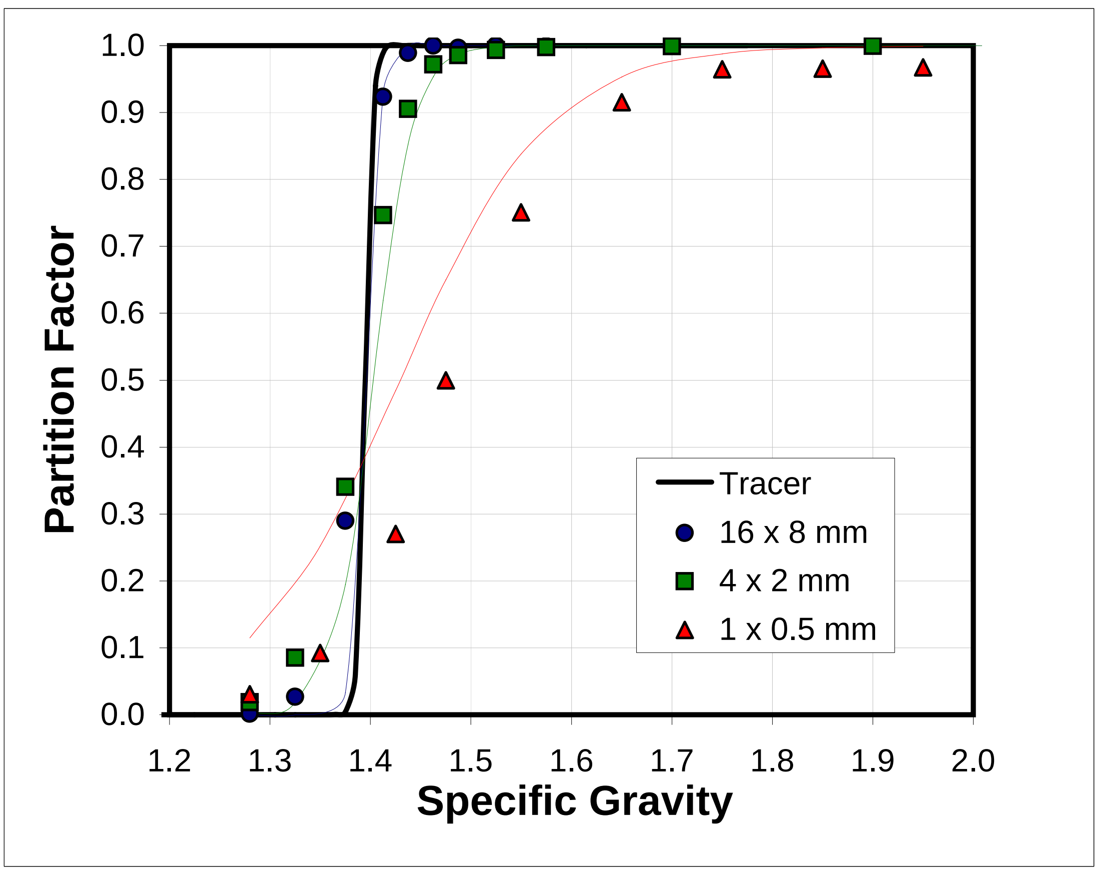


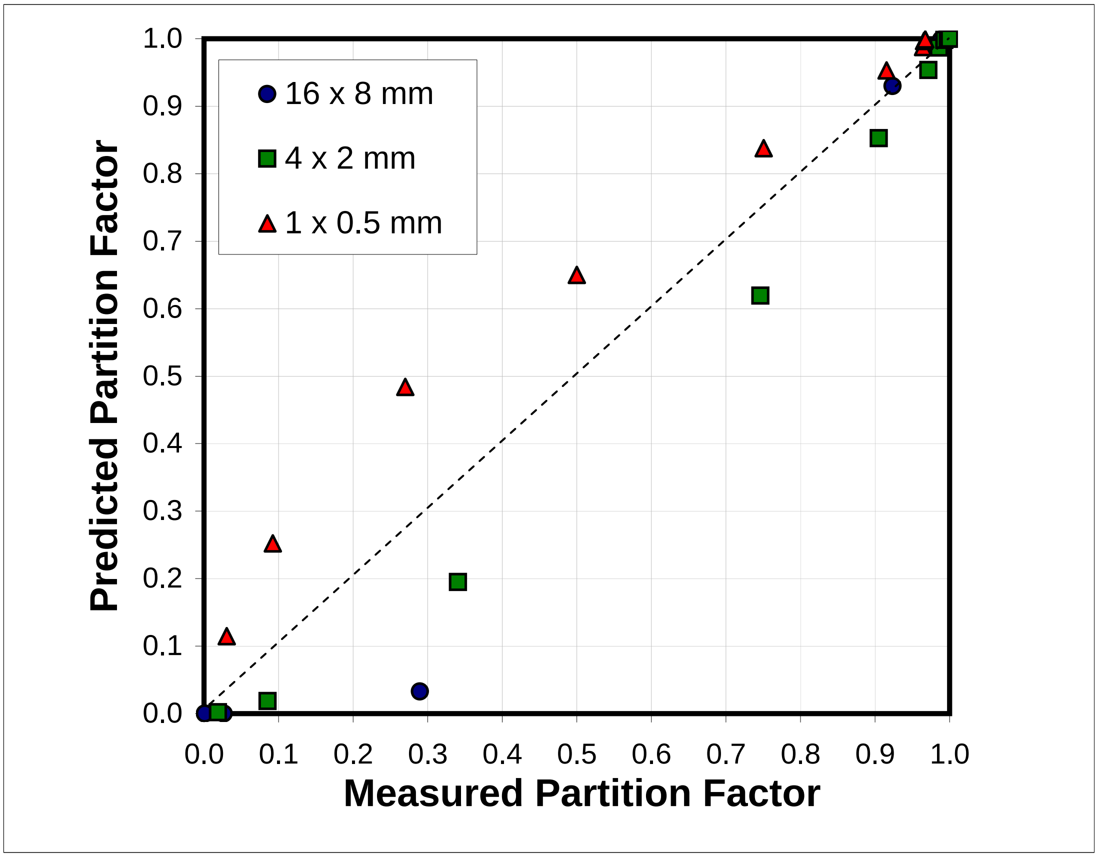


Circuit: CIRCUIT A2 - FINE COAL HMC CIRCUIT

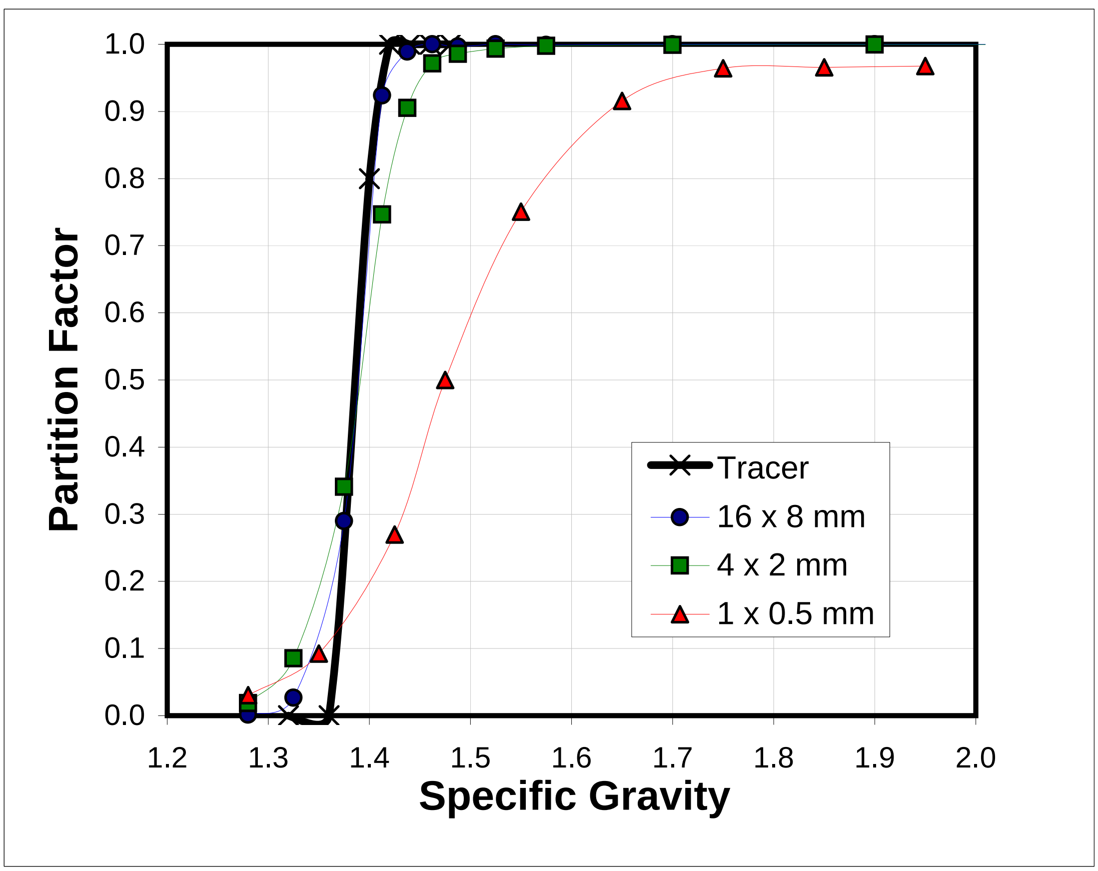
	Measured 16 x 8 mm	Predicted 16 x 8 mm		Measured 4 x 2 mm	Predicted 4 x 2 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.385	1.396	SG(50):	1.385	1.403	SG(50):	1.491	1.430
Ep:	0.012	0.007	Ep:	0.026	0.022	Ep:	0.071	0.080
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16 x 8 mm	Predicted 16 x 8 mm	SG	Measured 4 x 2 mm	Predicted 4 x 2 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.28	0.00	0.000	1.28	0.02	0.002	1.28	0.03	0.115
1.33	0.03	0.000	1.33	0.09	0.019	1.35	0.09	0.252
1.38	0.29	0.033	1.38	0.34	0.195	1.43	0.27	0.484
1.41	0.92	0.930	1.41	0.75	0.619	1.48	0.50	0.650
1.44	0.99	0.999	1.44	0.91	0.853	1.55	0.75	0.838
1.46	1.00	1.000	1.46	0.97	0.954	1.65	0.92	0.953
1.49	1.00	1.000	1.49	0.99	0.987	1.75	0.96	0.988
1.53	1.00	1.000	1.53	0.99	0.998	1.85	0.97	0.997
1.58	1.00	1.000	1.58	1.00	1.000	1.95	0.97	0.999
1.70	1.00	1.000	1.70	1.00	1.000			
1.90	1.00	1.000	1.90	1.00	1.000			
2.20	1.00	1.000	2.20	1.00	1.000			





Predicted Partition Factor
Measured Partition Factor
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0



Partition Factor
Specific Gravity
Tracer
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

PLANT A - HMC PERFORMANCE TEST

"COARSE CIRCUIT" - SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
CLEAN COAL	#1	1 OF 1	14,995.7	1,030.7	12,933.9	13,965.0	11,903.2	14.76%
CLEAN COAL	#2	1 OF 1	15,523.5	1,033.5	13,826.6	14,490.0	12,793.1	11.71%
CLEAN COAL	#3	1 OF 1	15,113.6	1,028.4	12,854.5	14,085.2	11,826.1	16.04%
CLEAN COAL	#4	1 OF 1	9,828.9	1,023.8	8,798.4	8,805.1	7,774.6	11.70%
CLEAN COAL	#5	1 OF 2	16,491.2	1,027.5	14,709.3	15,463.7	13,681.8	11.52%
CLEAN COAL	#5	2 of 2	4,180.3	1,031.9	3,892.1	3,148.4	2,860.2	9.15%
SUBTOTAL	#5	2	20,671.5	2,059.4	18,601.4	18,612.1	16,542.0	11.12%
TOTAL CLEAN	#5	6	76,133.2	6,175.8	67,014.8	69,957.4	60,839.0	13.03%
REFUSE	#1	1 OF 2	22,118.7	1,028.1	20,761.5	21,090.6	19,733.4	6.44%
REFUSE	#1	2 OF 2	11,169.0	1,031.5	10,532.7	10,137.5	9,501.2	6.28%
SUBTOTAL	#1	2	33,287.7	2,059.6	31,294.2	31,228.1	29,234.6	6.38%
REFUSE	#2	1 OF 2	27,052.5	1,026.8	25,456.0	26,025.7	24,429.2	6.13%
REFUSE	#2	2 OF 2	13,247.8	1,028.3	12,491.8	12,219.5	11,463.5	6.19%
SUBTOTAL	#2	2	40,300.3	2,055.1	37,947.8	38,245.2	35,892.7	6.15%
REFUSE	#3	1 OF 1	24,661.0	1,028.5	22,885.3	23,632.5	21,856.8	7.51%
REFUSE	#4	1 OF 1	20,464.9	1,030.2	19,011.7	19,434.7	17,981.5	7.48%
TOTAL REFUSE		6	118,713.9	6,173.4	111,139.0	112,540.5	104,965.6	6.73%

PLANT A - HMC PERFORMANCE TEST

"FINE CIRCUIT" - SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
FEED	1A	1 OF 2	19,466.2	1,033.1	17,482.9	18,433.1	16,449.8	10.76%
FEED	1A	2 of 2	19,813.3	1,027.6	17,777.4	18,785.7	16,749.8	10.84%
SUBTOTAL	1A	2	39,279.5	2,060.7	35,260.3	37,218.8	33,199.6	10.80%
FEED	2A	1 OF 2	22,037.8	1,031.8	20,069.6	21,006.0	19,037.8	9.37%
FEED	2A	2 of 2	21,231.7	1,030.9	19,084.1	20,200.8	18,053.2	10.63%
SUBTOTAL	2A	2	43,269.5	2,062.7	39,153.7	41,206.8	37,091.0	9.99%
TOTAL FEED	2A	4	82,549.0	4,123.4	74,414.0	78,425.6	70,290.6	10.37%
CLEAN COAL	#1	1 OF 1	14,748.8	1,035.5	12,217.0	13,713.3	11,181.5	18.46%
CLEAN COAL	#2	1 OF 1	19,016.4	1,037.0	16,080.0	17,979.4	15,043.0	16.33%
CLEAN COAL	#3	1 OF 1	15,509.5	1,039.9	12,985.0	14,469.6	11,945.1	17.45%
TOTAL CLEAN		3	49,274.7	3,112.4	41,282.0	46,162.3	38,169.6	17.31%
REFUSE	#1	1 OF 1	26,189.3	1,038.7	23,484.6	25,150.6	22,445.9	10.75%
REFUSE	#2	1 OF 1	20,796.0	1,041.2	18,556.2	19,754.8	17,515.0	11.34%
TOTAL REFUSE		2	46,985.3	2,079.9	42,040.8	44,905.4	39,960.9	11.01%

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES

FEED MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	7,678.8	TARE WT.	1,039.4
SOLIDS WT.	2,621.4	% SOLIDS	39.48%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,288	+ 25M	66.2	2.53%
968,289	25M x 0	2,555.2	97.47%
	Totals	2,621.4	100.00%

CLEAN COAL MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,113.5	TARE WT.	1,042.3
SOLIDS WT.	1,757.7	% SOLIDS	34.66%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,290	+ 25M	16.4	0.93%
968,291	25M x 0	1,741.3	99.07%
	Totals	1,757.7	100.00%

REFUSE MEDIA - COARSE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	7,047.2	TARE WT.	1,045.2
SOLIDS WT.	2,919.5	% SOLIDS	48.64%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,292	+ 25M	25.8	0.88%
968,293	25M x 0	2,893.7	99.12%
	Totals	2,919.5	100.00%

FEED MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,250.3	TARE WT.	1,035.8
SOLIDS WT.	1,849.2	% SOLIDS	35.46%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,294	+ 25M	34.8	1.88%
968,295	25M x 0	1,814.4	98.12%
	Totals	1,849.2	100.00%

CLEAN COAL MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	8,294.7	TARE WT.	1,032.2
SOLIDS WT.	2,102.1	% SOLIDS	28.94%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,296	+ 25M	43.2	2.06%
968,297	25M x 0	2,058.9	97.94%
	Totals	2,102.1	100.00%

REFUSE MEDIA - FINE CIRCUIT

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	6,863.5	TARE WT.	1,033.2
SOLIDS WT.	2,573.0	% SOLIDS	44.13%
LAB NO.	**SIZE**	**WT (Grams)**	**WT %**
968,298	+ 25M	22.4	0.87%
968,299	25M x 0	2,550.6	99.13%
	Totals	2,573.0	100.00%

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,362	**Lab #:**	970,362
Weights	Grams	**Weights**	Grams
Flask	81.7484	**Flask**	78.2091
Flask, Non-Mag, Mags	96.7836	**Flask, Non-Mag, Mags**	93.7151
Flask + Mags	91.3495	**Flask + Mags**	88.0789
% Mags:	63.86%	**% Mags:**	63.65%

RUN AVG:	**63.75%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,363	**Lab #:**	970,363
Weights	Grams	**Weights**	Grams
Flask	68.4724	**Flask**	67.1420
Flask, Non-Mag, Mags	83.7192	**Flask, Non-Mag, Mags**	82.7138
Flask + Mags	78.2137	**Flask + Mags**	77.1091
% Mags:	63.89%	**% Mags:**	64.01%

RUN AVG:	**63.95%**

TOT AVG:	**63.85%**

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 2 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,364	**Lab #:**	970,364
Weights	Grams	**Weights**	Grams
Flask	63.5954	**Flask**	68.1792
Flask, Non-Mag, Mags	78.7190	**Flask, Non-Mag, Mags**	83.7174
Flask + Mags	72.9513	**Flask + Mags**	77.8241
% Mags:	61.86%	**% Mags:**	62.07%

RUN AVG:	**61.97%**

ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,365	**Lab #:**	970,365
Weights	Grams	**Weights**	Grams
Flask	68.3089	**Flask**	63.5033
Flask, Non-Mag, Mags	83.7192	**Flask, Non-Mag, Mags**	78.7361
Flask + Mags	77.8573	**Flask + Mags**	72.9496
% Mags:	61.96%	**% Mags:**	62.01%

RUN AVG:	**61.99%**

TOT AVG:	**61.98%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 3 of 6

Plant:	**PLANT A**		
Circuit:	**COARSE CIRCUIT**		
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,366	**Lab #:**	970,366
Weights	Grams	**Weights**	Grams
Flask	67.1996	**Flask**	64.6445
Flask, Non-Mag, Mags	82.7260	**Flask, Non-Mag, Mags**	79.7268
Flask + Mags	78.3883	**Flask + Mags**	75.4975
% Mags:	72.06%	**% Mags:**	71.96%

RUN AVG:	**72.01%**

ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,367	**Lab #:**	970,367
Weights	Grams	**Weights**	Grams
Flask	67.4823	**Flask**	66.3560
Flask, Non-Mag, Mags	82.7127	**Flask, Non-Mag, Mags**	81.7193
Flask + Mags	78.4701	**Flask + Mags**	77.3751
% Mags:	72.14%	**% Mags:**	71.72%

RUN AVG:	**71.93%**

TOT AVG:	**71.97%**

PLANT A - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 4 of 6

Plant:	**PLANT A**		
Circuit:	**FINE CIRCUIT**		
ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,368	**Lab #:**	970,368
Weights	Grams	**Weights**	Grams
Flask	68.4161	**Flask**	67.0943
Flask, Non-Mag, Mags	83.7484	**Flask, Non-Mag, Mags**	82.7299
Flask + Mags	79.5999	**Flask + Mags**	78.4912
% Mags:	72.94%	**% Mags:**	72.89%

RUN AVG:	**72.92%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,369	**Lab #:**	970,369
Weights	Grams	**Weights**	Grams
Flask	67.3710	**Flask**	63.8125
Flask, Non-Mag, Mags	82.7308	**Flask, Non-Mag, Mags**	78.7282
Flask + Mags	78.6380	**Flask + Mags**	74.6836
% Mags:	73.35%	**% Mags:**	72.88%

RUN AVG:	**73.12%**

TOT AVG:	**73.02%**

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 5 of 6

Plant: PLANT A
Circuit: FINE CIRCUIT

ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,370	**Lab #:**	970,370
Weights	Grams	**Weights**	Grams
Flask	68.0970	**Flask**	68.0074
Flask, Non-Mag, Mags	83.7119	**Flask, Non-Mag, Mags**	83.7124
Flask + Mags	78.7294	**Flask + Mags**	78.6975
% Mags:	68.09%	**% Mags:**	68.07%

RUN AVG:	68.08%

ID:	**CLEAN COAL MEDIA**	**ID:**	**CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,371	**Lab #:**	970,371
Weights	Grams	**Weights**	Grams
Flask	67.7099	**Flask**	63.7018
Flask, Non-Mag, Mags	82.7330	**Flask, Non-Mag, Mags**	78.7448
Flask + Mags	77.9399	**Flask + Mags**	73.9186
% Mags:	68.10%	**% Mags:**	67.92%

RUN AVG:	68.01%

TOT AVG:	68.04%

PLANT A - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 6 of 6

Plant:	**PLANT A**		
Circuit:	**FINE CIRCUIT**		
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	970,372	**Lab #:**	970,372
Weights	Grams	**Weights**	Grams
Flask	65.2331	**Flask**	68.7366
Flask, Non-Mag, Mags	80.7953	**Flask, Non-Mag, Mags**	83.7987
Flask + Mags	78.3798	**Flask + Mags**	81.4530
% Mags:	84.48%	**% Mags:**	84.43%

RUN AVG:	**84.45%**

ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	970,373	**Lab #:**	970,373
Weights	Grams	**Weights**	Grams
Flask	64.7025	**Flask**	68.6499
Flask, Non-Mag, Mags	79.7612	**Flask, Non-Mag, Mags**	83.7198
Flask + Mags	77.3727	**Flask + Mags**	81.3507
% Mags:	84.14%	**% Mags:**	84.28%

RUN AVG:	**84.21%**

TOT AVG:	**84.33%**

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC FEED SAMPLE - SCREEN ANALYSIS

Combine all four (4) feed samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	70,290.6	Grams or	154.964	Lbs
START WEIGHT - REWEIGH:	155.2	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
11,215	39.66

Screen Analysis (Using 7 Containers) 135.8 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
11,216	+ 16mm	774.6	Grams	1.26%	65.45
11,217	*16 x 8mm*	17,969.9	Grams	29.30%	44.64
11,218	8 x 4mm	13,268.7	Grams	21.64%	38.67
Totals	**+4mm**	**32,013.2**	**Grams**	**52.20%**	**42.67**

Total +4mm Wt	32,013.2	Grams	52.20%			
Total -4mm Wt	29,309.2	Grams	47.80%			
Total Wt	61,322.4	Grams	100.00%	or	135.2	Lbs
Screen Loss	275.4	Grams		or	0.45	%
-4mm Split Wt	29,309.2	Grams	(Use All)			
Screen Loss	43.2	Grams		or	0.15	%
Total Scr Loss	318.6	Grams		or	0.52	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
11,219	*4 x 2mm*	19,853.8	Grams	32.42%	37.71
11,220	2 x 1mm	6,278.1	Grams	10.25%	36.60
11,221	*1 x 0.5mm*	1,634.5	Grams	2.67%	32.06
11,222	0.5mm x 0	1,499.6	Grams	2.45%	42.80
Totals	**4mm x 0**	**29,266.0**	**Grams**	**47.80%**	**37.42**
Totals	**+16mm x 0**	**61,279.2**	**Grams**	**100.00%**	**40.16**

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	13,507.4	Grams			
LOSS:	27.2	Grams	or	0.20	%

LAB #	GRAVITY	WT	Units	WT%
11,223	1.300	4,382.5	Grams	32.51%
11,224	1.350	1,273.0	Grams	9.44%
11,225	1.400	527.0	Grams	3.91%
11,226	1.425	140.2	Grams	1.04%
11,227	1.450	71.0	Grams	0.53%
11,228	1.475	151.1	Grams	1.12%
11,229	1.500	81.4	Grams	0.60%
11,230	1.550	119.1	Grams	0.88%
11,231	1.600	112.1	Grams	0.83%
11,232	1.800	368.9	Grams	2.74%
11,233	2.000	385.1	Grams	2.86%
11,234	SINK	5,868.8	Grams	43.54%
TOTAL		13,480.2	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	14,909.2	Grams			
LOSS:	22.1	Grams	or	0.15	%

LAB #	GRAVITY	WT	Units	WT%
12,094	1.300	6,192.6	Grams	41.60%
12,095	1.350	1,168.6	Grams	7.85%
12,096	1.400	582.3	Grams	3.91%
12,097	1.425	189.9	Grams	1.28%
12,098	1.450	128.0	Grams	0.86%
12,099	1.475	102.5	Grams	0.69%
12,100	1.500	87.8	Grams	0.59%
12,101	1.550	149.9	Grams	1.01%
12,102	1.600	152.5	Grams	1.02%
12,103	1.800	355.8	Grams	2.39%
12,104	2.000	362.6	Grams	2.44%
12,105	SINK	5,414.6	Grams	36.37%
TOTAL		14,887.1	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	1,240.5	Grams			
LOSS:	3.3	Grams	or	0.27	%

LAB #	GRAVITY	WT	Units	WT%
12,926	1.300	585.3	Grams	47.31%
12,927	1.400	142.1	Grams	11.49%
12,928	1.450	27.8	Grams	2.25%
12,929	1.500	17.6	Grams	1.42%
12,930	1.600	21.7	Grams	1.75%
12,931	1.700	15.3	Grams	1.24%
12,932	1.800	12.3	Grams	0.99%
12,933	1.900	10.3	Grams	0.83%
12,934	2.000	12.5	Grams	1.01%
12,935	SINK	392.3	Grams	31.71%
TOTAL		1,237.2	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all three (3) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	38,169.6	Grams or	84.150	Lbs
START WEIGHT - REWEIGH:	84.2		Lbs	

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
13,215	3.58

Screen Analysis (Using 7 Containers) 73.70 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
13,216	+ 16mm	108.1	Grams	0.32%	6.38
13,217	*16 x 8mm*	8,813.1	Grams	26.38%	4.09
13,218	8 x 4mm	11,034.4	Grams	33.02%	3.52
Totals	**+4mm**	**19,955.6**	**Grams**	**59.72%**	**3.79**

Total +4mm Wt	19,955.6	Grams	59.72%			
Total -4mm Wt	13,458.3	Grams	40.28%			
Total Wt	33,413.9	Grams	100.00%	or	73.7	Lbs
Screen Loss	15.9	Grams		or	0.05	%
-4mm Split Wt	13,458.3	Grams	(Use All)			
Screen Loss	8.8	Grams		or	0.07	%
Total Scr Loss	24.7	Grams		or	0.07	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
13,219	*4 x 2mm*	8,858.9	Grams	26.53%	3.20
13,220	2 x 1mm	3,774.7	Grams	11.30%	3.16
13,221	*1 x 0.5mm*	691.3	Grams	2.07%	3.34
13,222	0.5mm x 0	124.6	Grams	0.37%	16.16
Totals	**4mm x 0**	**13,449.5**	**Grams**	**40.28%**	**3.32**

Totals	**+16mm x 0**	**33,405.1**	**Grams**	**100.00%**	**3.60**

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	6,583.2	Grams			
LOSS:	8.2	Grams	or	0.12	%

LAB #	GRAVITY	WT	Units	WT%
15,077	1.300	5,212.3	Grams	79.27%
15,078	1.350	1,074.2	Grams	16.34%
15,079	1.400	275.9	Grams	4.20%
15,080	1.425	11.0	Grams	0.17%
15,081	1.450	1.3	Grams	0.02%
	1.475		Grams	0.00%
15,082	1.500	0.2	Grams	0.00%
	1.550		Grams	0.00%
15,083	1.600	0.1	Grams	0.00%
	1.800		Grams	0.00%
	2.000		Grams	0.00%
	SINK		Grams	0.00%
TOTAL		6,575.0	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	6,649.1	Grams			
LOSS:	25.8	Grams	or	0.39	%

LAB #	GRAVITY	WT	Units	WT%
15,574	1.300	5,529.0	Grams	83.48%
15,575	1.350	828.0	Grams	12.50%
15,576	1.400	224.8	Grams	3.39%
15,577	1.425	27.7	Grams	0.42%
15,578	1.450	9.1	Grams	0.14%
15,579	1.475	2.2	Grams	0.03%
15,580	1.500	0.9	Grams	0.01%
15,581	1.550	0.8	Grams	0.01%
15,582	1.600	0.2	Grams	0.00%
15,583	1.800	0.3	Grams	0.00%
15,584	2.000	0.1	Grams	0.00%
15,585	SINK	0.2	Grams	0.00%
TOTAL		6,623.3	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm			
START WT:	515.6	Grams		
LOSS:	1.8	Grams	or 0.35	%

LAB #	GRAVITY	WT	Units	WT%
15,586	1.300	422.4	Grams	82.21%
15,587	1.400	77.2	Grams	15.03%
15,588	1.450	8.3	Grams	1.62%
15,589	1.500	2.8	Grams	0.54%
15,590	1.600	1.5	Grams	0.29%
15,591	1.700	0.3	Grams	0.06%
15,592	1.800	0.1	Grams	0.02%
15,593	1.900	0.1	Grams	0.02%
15,594	2.000	0.1	Grams	0.02%
15,595	SINK	1.0	Grams	0.19%
TOTAL		513.8	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all two (2) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	39,960.9	Grams or	88.099	Lbs
START WEIGHT - REWEIGH:	88.1		Lbs	

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
12,936	76.53

Screen Analysis (Using 7 Containers) 77.0 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
12,937	+ 16mm	602.9	Grams	1.73%	86.35
12,938	*16 x 8mm*	11,904.4	Grams	34.19%	78.45
12,939	8 x 4mm	11,060.2	Grams	31.77%	76.97
Totals	+4mm	23,567.5	Grams	67.70%	77.96

Total +4mm Wt	23,567.5	Grams	67.70%			
Total -4mm Wt	11,246.0	Grams	32.30%			
Total Wt	34,813.5	Grams	100.00%	or	76.8	Lbs
Screen Loss	113.1	Grams		or	0.32	%
-4mm Split Wt	11,246.0	Grams	(Use All)			
Screen Loss	59.9	Grams		or	0.53	%
Total Scr Loss	173.0	Grams		or	0.50	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
12,940	*4 x 2mm*	8,846.2	Grams	25.55%	75.16
12,941	2 x 1mm	1,990.7	Grams	5.75%	73.60
12,942	*1 x 0.5mm*	214.5	Grams	0.62%	67.82
12,943	0.5mm x 0	134.7	Grams	0.39%	66.99
Totals	4mm x 0	11,186.1	Grams	32.30%	74.64

Totals	+16mm x 0	34,753.6	Grams	100.00%	76.89

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	8,991.5	Grams			
LOSS:	2.1	Grams	or	0.02	%

LAB #	GRAVITY	WT	Units	WT%
13,223	1.300	8.2	Grams	0.09%
13,224	1.350	33.0	Grams	0.37%
13,225	1.400	125.7	Grams	1.40%
13,226	1.425	148.8	Grams	1.66%
13,227	1.450	131.1	Grams	1.46%
13,228	1.475	91.7	Grams	1.02%
13,229	1.500	66.6	Grams	0.74%
13,230	1.550	150.1	Grams	1.67%
13,231	1.600	121.8	Grams	1.35%
13,232	1.800	411.7	Grams	4.58%
13,233	2.000	450.9	Grams	5.02%
13,234	SINK	7,249.8	Grams	80.65%
TOTAL		8,989.4	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	6,707.8	Grams			
LOSS:	11.3	Grams	or	0.17	%

LAB #	GRAVITY	WT	Units	WT%
14,236	1.300	117.5	Grams	1.75%
14,237	1.350	85.8	Grams	1.28%
14,238	1.400	129.2	Grams	1.93%
14,239	1.425	90.7	Grams	1.35%
14,240	1.450	96.6	Grams	1.44%
14,241	1.475	83.8	Grams	1.25%
14,242	1.500	69.8	Grams	1.04%
14,243	1.550	129.6	Grams	1.94%
14,244	1.600	98.0	Grams	1.46%
14,245	1.800	343.0	Grams	5.12%
14,246	2.000	273.5	Grams	4.08%
14,247	SINK	5,179.0	Grams	77.34%
TOTAL		6,696.5	Grams	100.00%

CIRCUIT A2 - HMC PERFORMANCE TEST

FINE HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	161.1	Grams			
LOSS:	0.4	Grams	or	0.25	%

LAB #	GRAVITY	WT	Units	WT%
14,642	1.300	14.7	Grams	9.15%
14,643	1.400	8.7	Grams	5.41%
14,644	1.450	3.4	Grams	2.12%
14,645	1.500	3.1	Grams	1.93%
14,646	1.600	5.0	Grams	3.11%
14,647	1.700	3.6	Grams	2.24%
14,648	1.800	3.0	Grams	1.87%
14,649	1.900	3.1	Grams	1.93%
14,650	2.000	3.3	Grams	2.05%
14,651	SINK	112.8	Grams	70.19%
TOTAL		160.7	Grams	100.00%

APPENDIX II-B

Partitioning Data for Plant B
(Coarse and Fine DMC Circuits)

Test Description: CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT

Feed Coal Type: Sewell

	Body	Vortex	Apex
Manufacturer:	Krebs	Krebs	Krebs
Diameter (Inch):	33	14	11.57
Wear Condition:	Fair	Good	Excellen
Part Alignment:			Good

Plant Feed Rate (tph):	595	
Circuit Feed Rate(tph):	435	
Inlet Pressure (psi):	14.5	
Gauge Position (inch):	-25	
Head (Diameters):	7.2	LOW!
Magnetite Grade:	B	

Tracer Size (mm):	32
Tracer Shape:	Cubes
Weighting (Y/N)?	N
SG Cutpoint (SG50)	1.750
Probable Error (Ep):	0.012
Low SG Offset:	0.000

Tracer SG	Tracer in Feed	Overflow (Clean Coal) A	B	C	D	E	F	Sum	Underflow (Refuse) A	B	C	D	E	F	Sum	Tracers Collected	Tracers Lost	Refuse Partition	Fitted Partition	Weight Factor	Weighted Error
1.50	40	22	16					38	0						0	0.95	0.05	0.00	0.00	0.10	0.00
1.66	40	16	16					32	0						0	0.80	0.20	0.00	0.00	0.10	0.00
1.68	40	22	9					31	0						0	0.78	0.23	0.00	0.00	0.10	0.00
1.70	40	14	14					28	0						0	0.70	0.30	0.00	0.01	0.10	0.00
1.72	40	19	13					32	2						2	0.85	0.15	0.06	0.06	0.10	0.00
1.74	40	13	9					22	12						12	0.85	0.15	0.35	0.29	0.35	0.00
1.76	40	6	1					7	24						24	0.78	0.23	0.77	0.71	0.23	0.00
1.78	40	0	1					1	27						27	0.70	0.30	0.96	0.94	0.10	0.00
1.80	40	0	0					0	31						31	0.78	0.23	1.00	0.99	0.10	0.00
Known Dropped		0	0					0	0						0					Total WSSQ:	0.01

Description: CIRCUIT B1 - PRIMARY COARSE COAL HMC

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections Real World	Ep Corrections O&M Factors	Ep Corrections Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1.2	0.010	0.013
16	8	11.31	0.003	1.5	1.2	0.010	0.016
8	4	5.66	0.007	1.5	1.2	0.010	0.022
4	2	2.83	0.013	1.5	1.2	0.010	0.034
2	1	1.41	0.026	1.5	1.2	0.010	0.057
1	0.5	0.71	0.052	1.5	1.2	0.010	0.104

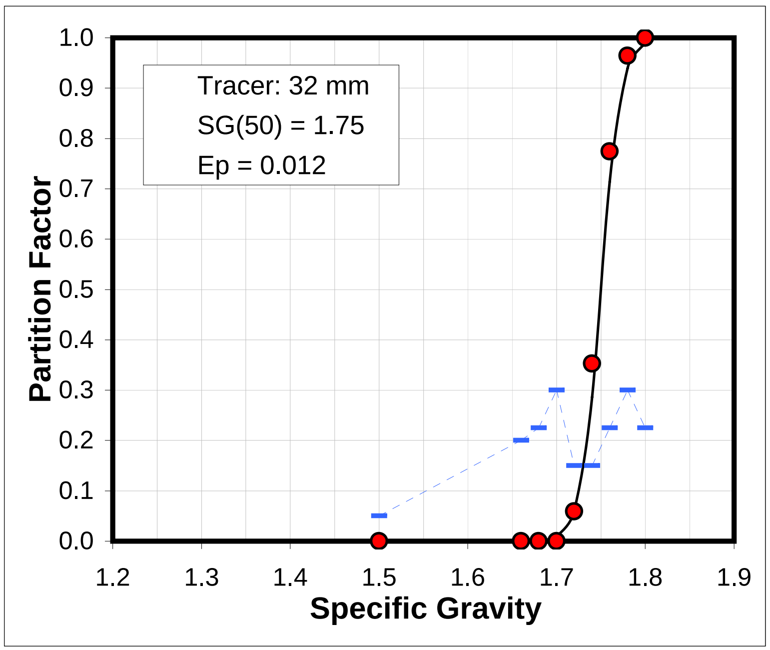
Comments: O&M correction for low pressure.

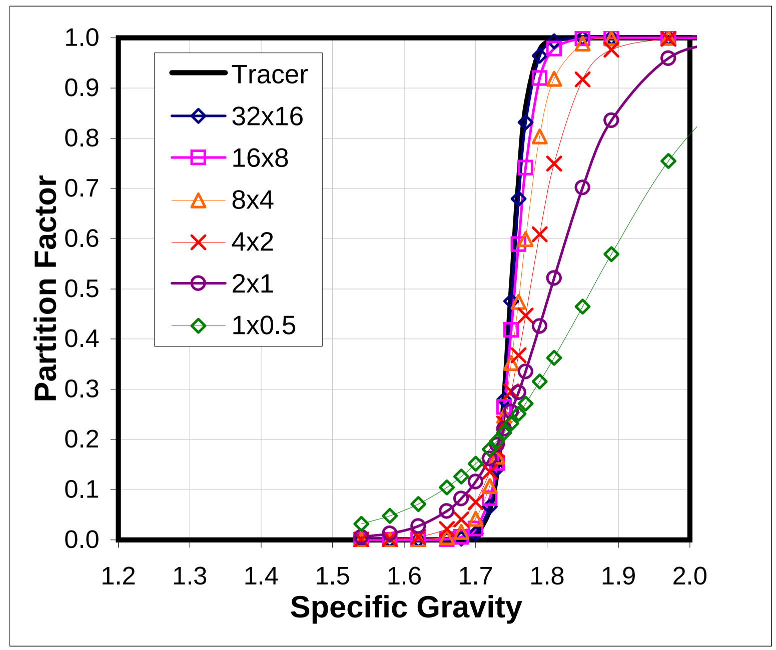
	SG	Split
O/F:	1.445	0.795
U/F:	1.810	0.205
Feed:	1.520	1.000

	SG	Split
Pivot:	1.735	0.205
O/F-U/F	0.37	

Obs.	Marcy Scale SG Feed	Marcy Scale SG O/F	Marcy Scale SG U/F
1	1.52	1.43	1.81
2		1.46	
3			
4			
5			
Avg.	1.520	1.445	1.810

Size	32	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.750	1.751	1.755	1.762	1.777	1.806	1.863
Ep	0.012	0.013	0.016	0.022	0.034	0.057	0.104
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





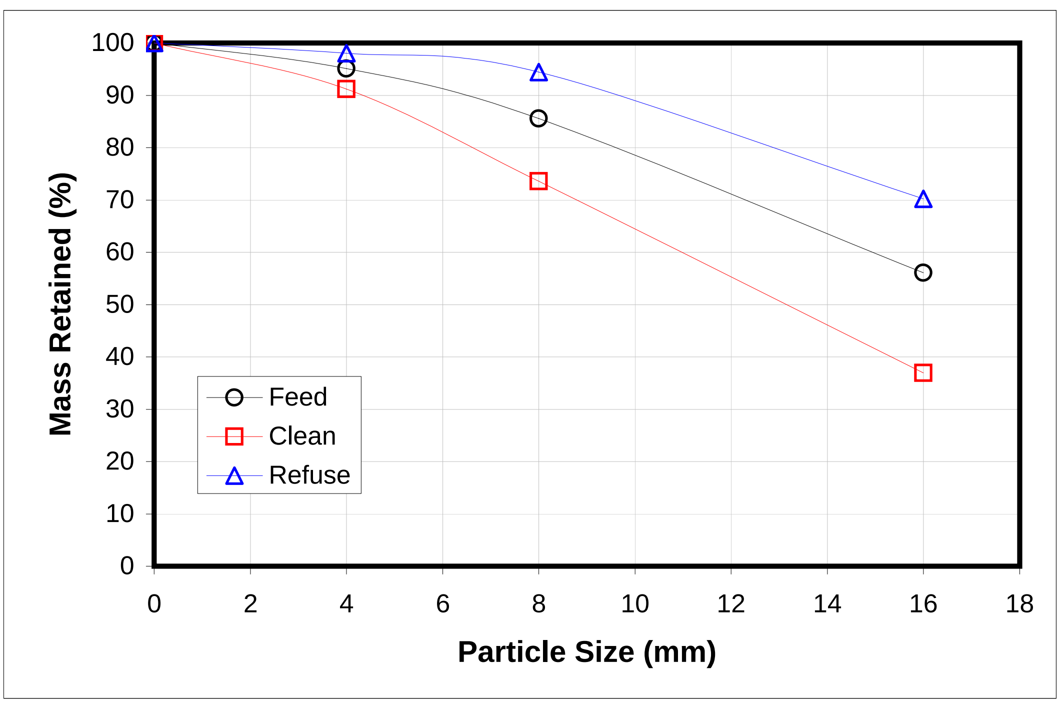
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	184.5	Clean Yield (%):	42.41	0.80335	0.38155
Refuse Rate (t/hr):	250.5	Refuse Yield (%):	57.59	0.63498	0.20369
Feed Rate (t/hr):	435.0			0.73625	0.13579

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	36.94	13.03	70.23	84.07	56.11	64.23
16	8	11.31	36.61	8.59	24.19	83.94	29.45	44.22
8	4	5.66	17.63	5.89	3.60	86.78	9.55	23.45
4	0	0.00	8.82	4.98	1.98	81.18	4.88	22.81
		Totals	100.00	9.44	100.00	84.08	100.00	52.42

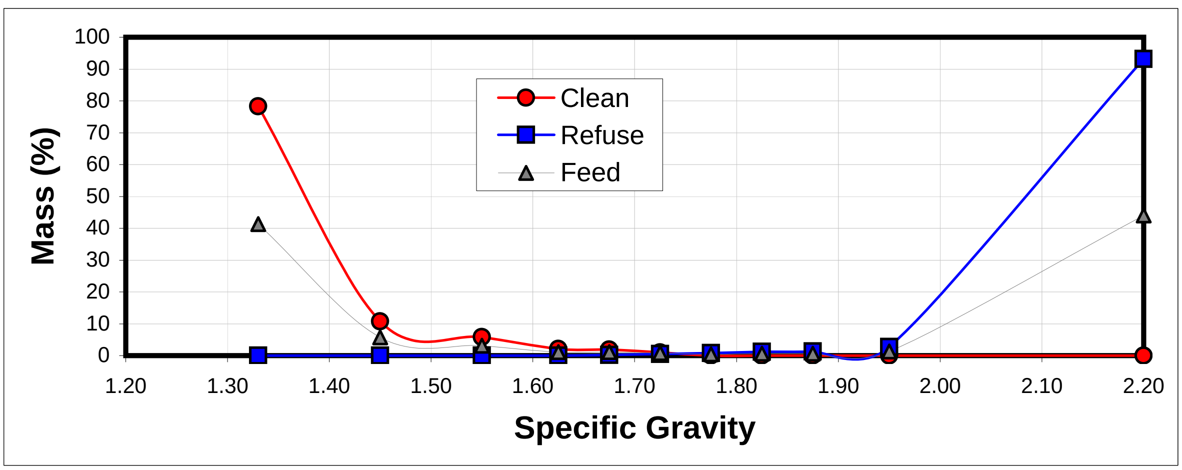
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	27.92	72.08	100.00	36.94	70.23	56.11
16	8	11.31	52.71	47.29	100.00	73.55	94.41	85.56
8	4	5.66	78.29	21.71	100.00	91.18	98.02	95.12
4	0	0.00	76.60	23.40	100.00	100.00	100.00	100.00
		Totals	42.41	57.59	100.00			

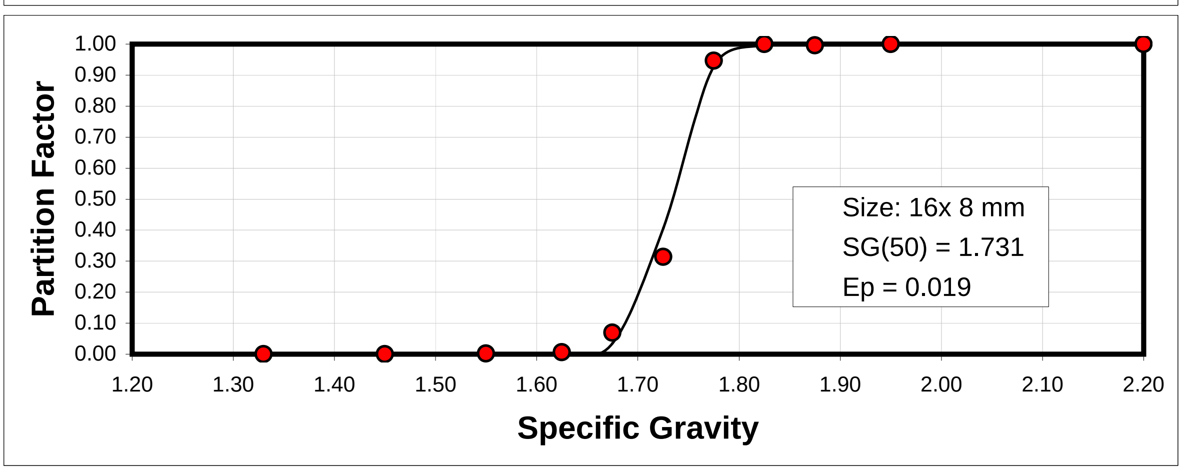


Circuit:	CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT
Size:	16x 8 mm

Clean Yield (%)	52.71	SG Cutpoint (SG50)	1.731	Weighting (Y/N)?	Y
Refuse Yield (%)	47.29	Probable Error (Ep):	0.019	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	78.264	0.00	41.26	0.00	0.00	0.10	0.00
1.400	1.500	1.450	10.779	0.00	5.68	0.00	0.00	0.10	0.00
1.500	1.600	1.550	5.857	0.01	3.09	0.00	0.00	0.10	0.00
1.600	1.650	1.625	2.108	0.02	1.12	0.01	0.00	0.10	0.00
1.650	1.700	1.675	1.938	0.16	1.10	0.07	0.03	0.10	0.12
1.700	1.750	1.725	1.003	0.51	0.77	0.31	0.41	0.31	0.09
1.750	1.800	1.775	0.042	0.83	0.41	0.95	0.93	0.10	0.03
1.800	1.850	1.825	0.000	1.25	0.59	1.00	1.00	0.10	0.00
1.850	1.900	1.875	0.004	1.30	0.62	1.00	1.00	0.10	0.00
1.900	2.000	1.950	0.000	2.75	1.30	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.004	93.17	44.06	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.24

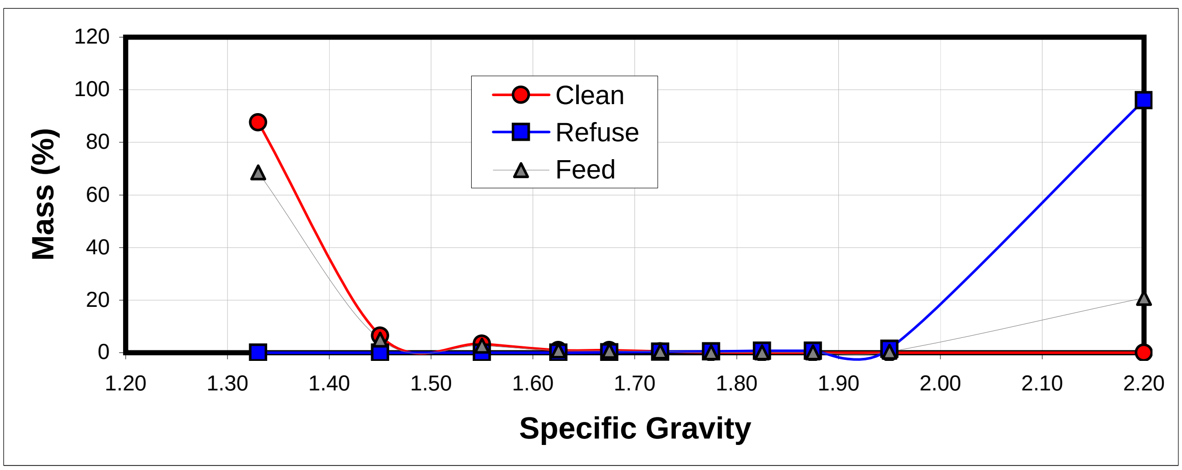


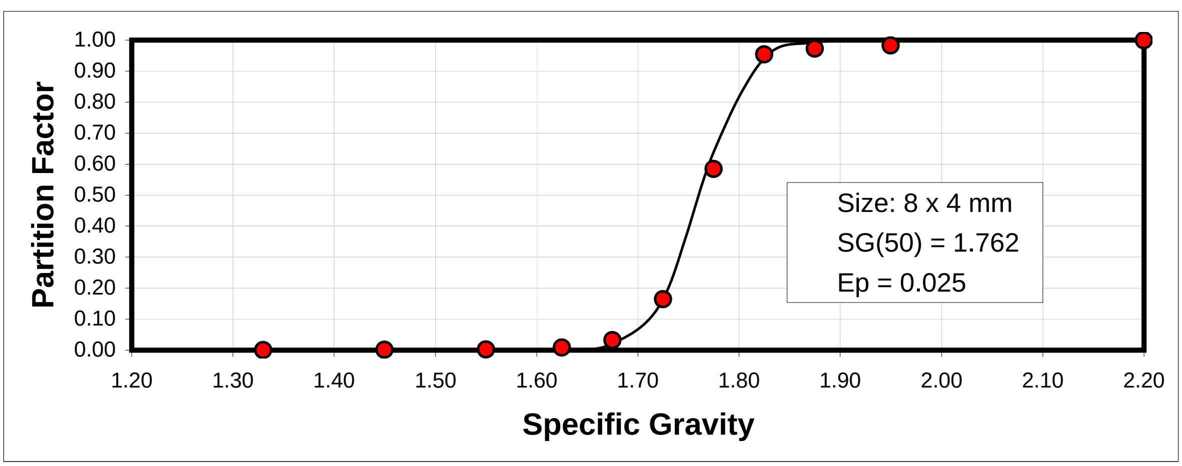


Circuit: CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT
Size: 8 x 4 mm

Clean Yield (%)	78.29	SG Cutpoint (SG50)	1.762	Weighting (Y/N)?	Y
Refuse Yield (%)	21.71	Probable Error (Ep):	0.025	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	87.63	0.05	68.62	0.00	0.00	0.10	0.00
1.400	1.500	1.450	6.41	0.02	5.02	0.00	0.00	0.10	0.00
1.500	1.600	1.550	3.35	0.03	2.63	0.00	0.00	0.10	0.00
1.600	1.650	1.625	1.03	0.03	0.82	0.01	0.00	0.10	0.00
1.650	1.700	1.675	0.95	0.11	0.76	0.03	0.02	0.10	0.01
1.700	1.750	1.725	0.50	0.35	0.47	0.16	0.16	0.16	0.00
1.750	1.800	1.775	0.09	0.48	0.18	0.58	0.64	0.42	0.02
1.800	1.850	1.825	0.01	0.71	0.16	0.95	0.94	0.10	0.02
1.850	1.900	1.875	0.01	0.71	0.16	0.97	0.99	0.10	0.04
1.900	2.000	1.950	0.01	1.50	0.33	0.98	1.00	0.10	0.03
2.000	2.400	2.200	0.02	96.02	20.86	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.12

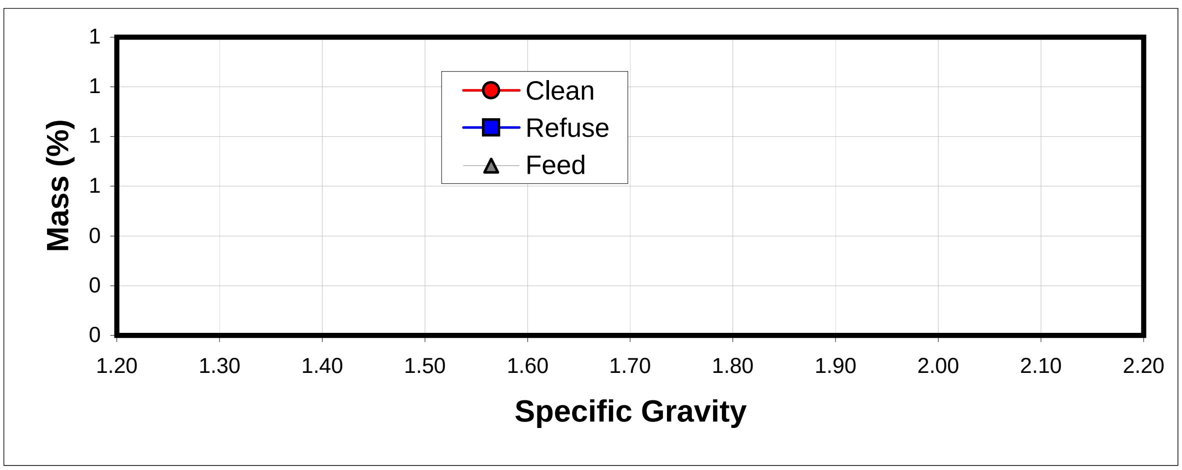


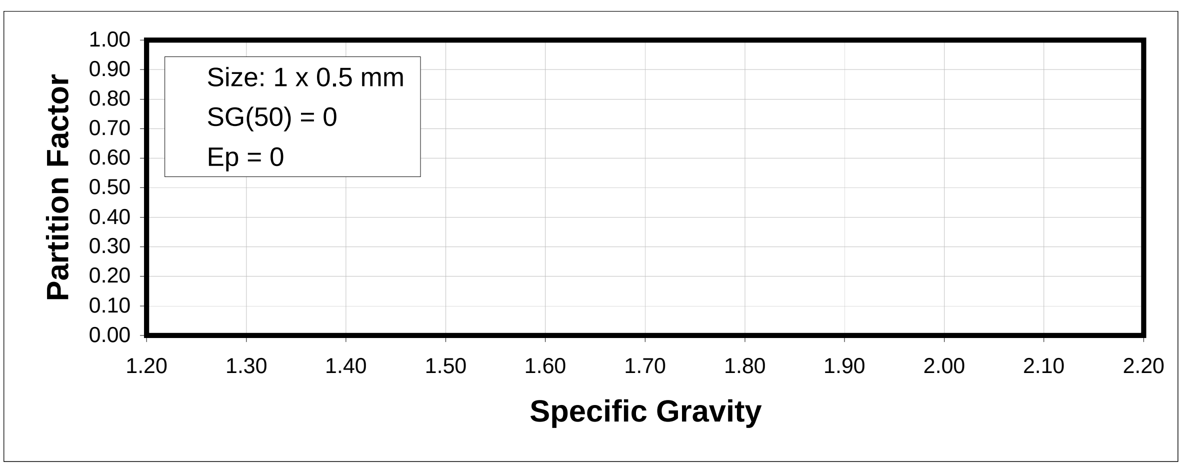


Circuit:	CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT
Size:	1 x 0.5 mm

Clean Yield (%)	0.00	SG Cutpoint (SG50):		Weighting (Y/N)?	
Refuse Yield (%)	100.00	Probable Error (Ep):		Low SG Offset:	

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330							
1.400	1.500	1.450							
1.500	1.600	1.550							
1.600	1.650	1.625							
1.650	1.700	1.675							
1.700	1.750	1.725							
1.750	1.800	1.775							
1.800	1.850	1.825							
1.850	1.900	1.875							
1.900	2.000	1.950							
2.000	2.400	2.200							
		Totals	0.00	0.00	0.00			WSSQ:	0.00

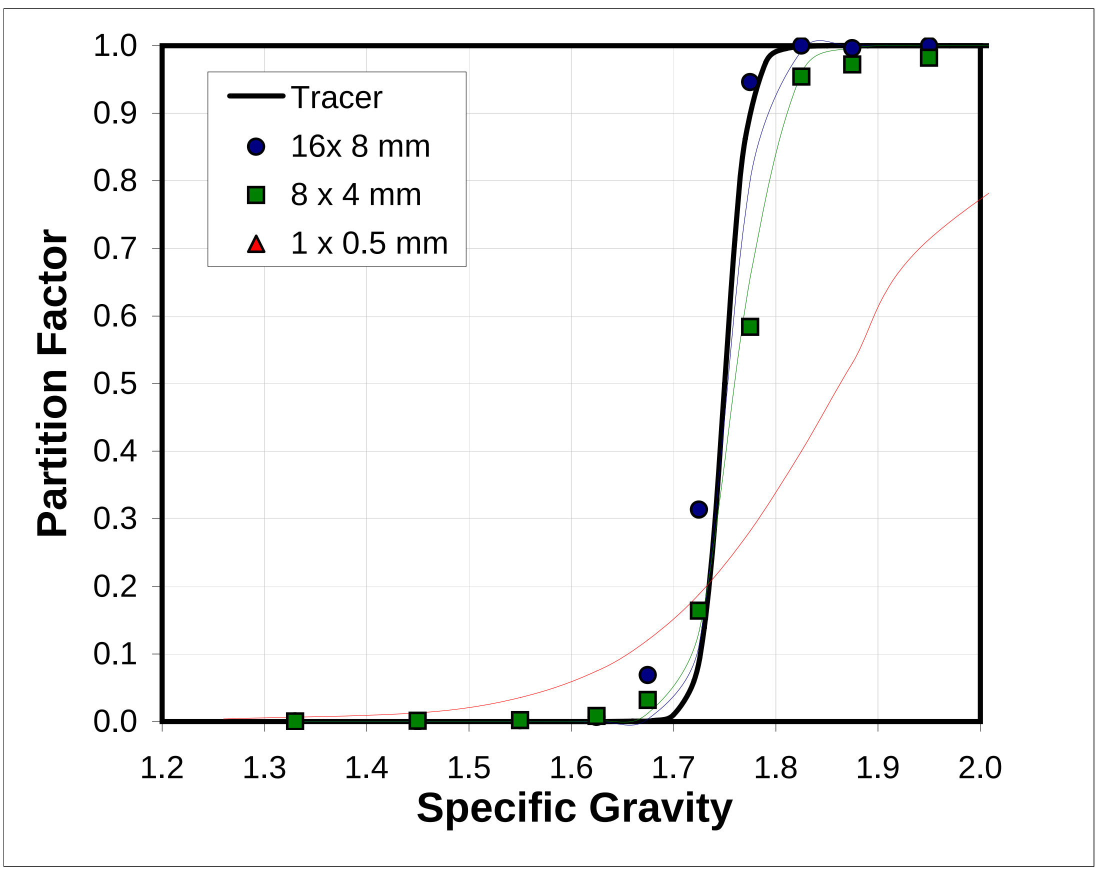


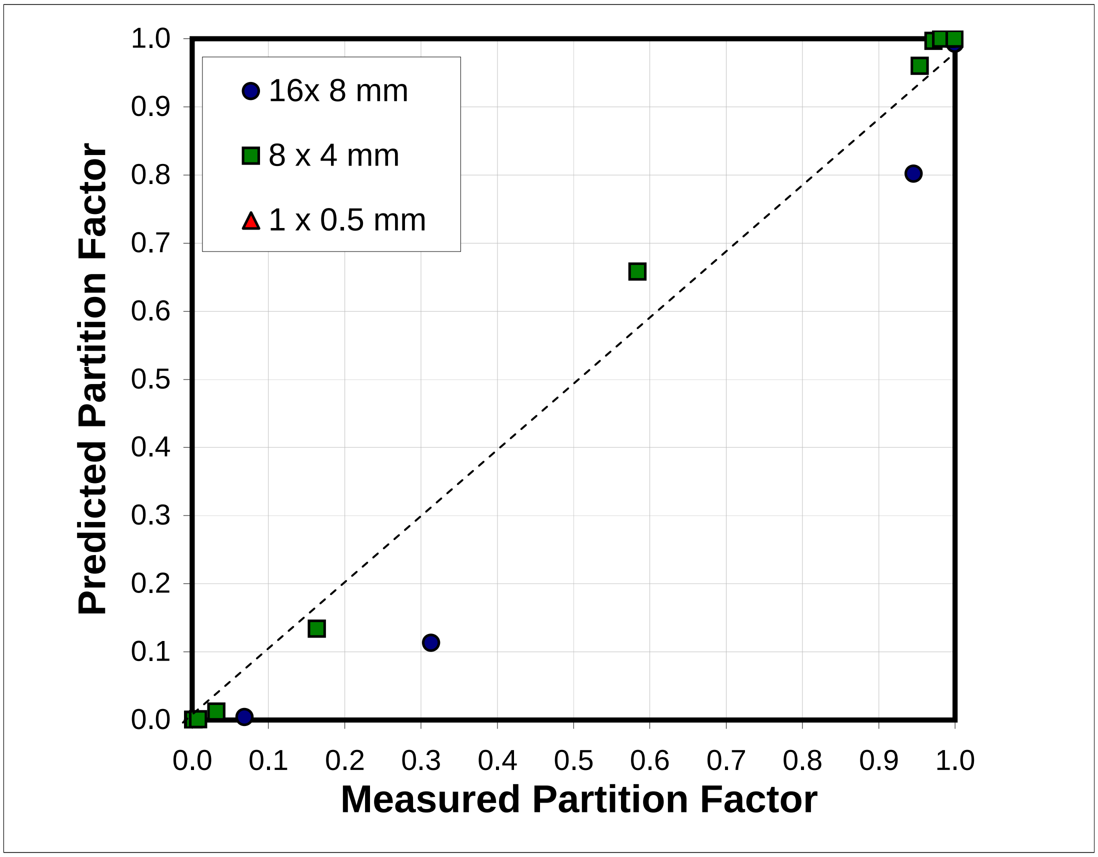


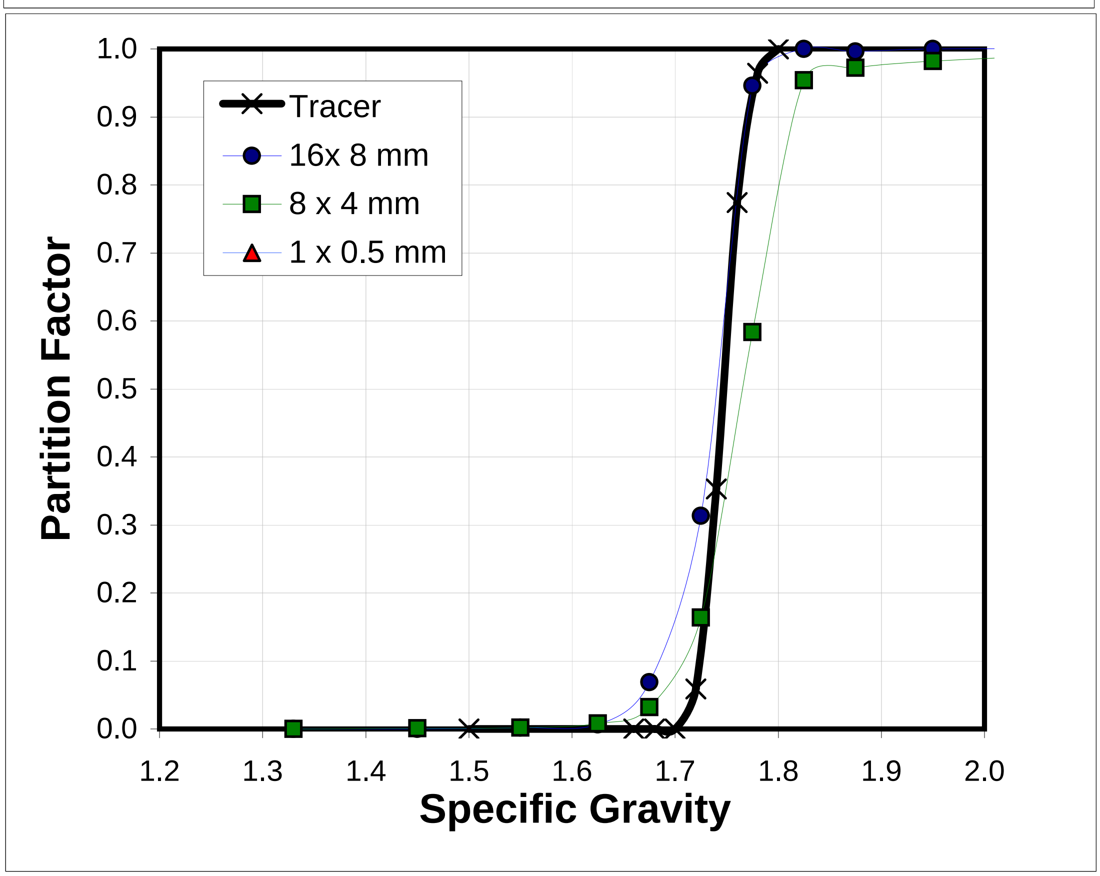
Circuit: CIRCUIT B1 - PRIMARY COARSE COAL HMC CIRCUIT

	Measured 16x 8 mm	Predicted 16x 8 mm		Measured 8 x 4 mm	Predicted 8 x 4 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.731	1.755	SG(50):	1.762	1.762	SG(50):	0.000	1.863
Ep:	0.019	0.016	Ep:	0.025	0.022	Ep:	0.000	0.104
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16x 8 mm	Predicted 16x 8 mm	SG	Measured 8 x 4 mm	Predicted 8 x 4 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.33	0.00	0.000	1.33	0.00	0.000	1.26		0.004
1.45	0.00	0.000	1.45	0.00	0.000	1.45		0.013
1.55	0.00	0.000	1.55	0.00	0.000	1.55		0.035
1.63	0.01	0.000	1.63	0.01	0.001	1.63		0.075
1.68	0.07	0.004	1.68	0.03	0.012	1.68		0.121
1.73	0.31	0.113	1.73	0.16	0.134	1.73		0.188
1.78	0.95	0.802	1.78	0.58	0.658	1.78		0.282
1.83	1.00	0.992	1.83	0.95	0.960	1.83		0.400
1.88	1.00	1.000	1.88	0.97	0.997	1.88		0.530
1.95	1.00	1.000	1.95	0.98	1.000	1.95		0.713
2.20	1.00	1.000	2.20	1.00	1.000	2.20		0.972




16x 8 mm
8 x 4 mm
1 x 0.5 mm
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Predicted Partition Factor
Measured Partition Factor


Tracer
16x 8 mm
8 x 4 mm
1 x 0.5 mm
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Partition Factor
Specific Gravity

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 7

Plant:	**CIRCUIT B1**		
ID:	**PRIMARY FEED MEDIA**	**ID:**	**PRIMARY FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,573	**Lab #:**	32,573
Weights	Grams	**Weights**	Grams
Flask	68.3073	**Flask**	63.5024
Flask, Non-Mag, Mags	83.8126	**Flask, Non-Mag, Mags**	78.8842
Flask + Mags	81.4310	**Flask + Mags**	76.4946
% Mags:	84.64%	**% Mags:**	84.46%

RUN AVG:	**84.55%**

ID:	**PRIMARY FEED MEDIA**	**ID:**	**PRIMARY FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,574	**Lab #:**	32,574
Weights	Grams	**Weights**	Grams
Flask	67.1983	**Flask**	64.6442
Flask, Non-Mag, Mags	82.8569	**Flask, Non-Mag, Mags**	79.8407
Flask + Mags	80.3074	**Flask + Mags**	77.3384
% Mags:	83.72%	**% Mags:**	83.53%

RUN AVG:	**83.63%**
TOT AVG:	**84.09%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 2 of 7

Plant:	**CIRCUIT B1**		
ID:	**PRIM. CLEAN COAL #1 MEDIA**	**ID:**	**PRIM. CLEAN COAL #1 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,575	**Lab #:**	32,575
Weights	Grams	**Weights**	Grams
Flask	67.4813	**Flask**	66.3542
Flask, Non-Mag, Mags	82.8097	**Flask, Non-Mag, Mags**	81.8531
Flask + Mags	80.2628	**Flask + Mags**	79.2678
% Mags:	83.38%	**% Mags:**	83.32%

RUN AVG:	**83.35%**

ID:	**PRIM. CLEAN COAL #1 MEDIA**	**ID:**	**PRIM. CLEAN COAL #1 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,576	**Lab #:**	32,576
Weights	Grams	**Weights**	Grams
Flask	68.4144	**Flask**	67.0930
Flask, Non-Mag, Mags	83.8812	**Flask, Non-Mag, Mags**	82.8293
Flask + Mags	81.2839	**Flask + Mags**	80.1496
% Mags:	83.21%	**% Mags:**	82.97%

RUN AVG:	**83.09%**

TOT AVG:	**83.22%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 3 of 7

Plant:	**CIRCUIT B1**		
ID:	**PRIM. CLEAN COAL #2 MEDIA**	**ID:**	**PRIM. CLEAN COAL #2 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,577	**Lab #:**	32,577
Weights	Grams	**Weights**	Grams
Flask	67.3700	**Flask**	63.8114
Flask, Non-Mag, Mags	82.8024	**Flask, Non-Mag, Mags**	78.8073
Flask + Mags	80.0937	**Flask + Mags**	76.1772
% Mags:	82.45%	**% Mags:**	82.46%

RUN AVG:	**82.45%**

ID:	**PRIM. CLEAN COAL #2 MEDIA**	**ID:**	**PRIM. CLEAN COAL #2 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,578	**Lab #:**	32,578
Weights	Grams	**Weights**	Grams
Flask	68.0960	**Flask**	68.0063
Flask, Non-Mag, Mags	83.8224	**Flask, Non-Mag, Mags**	83.8224
Flask + Mags	81.0730	**Flask + Mags**	81.0375
% Mags:	82.52%	**% Mags:**	82.39%

RUN AVG:	**82.45%**

TOT AVG:	**82.45%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 4 of 7

Plant:	**CIRCUIT B1**		
ID:	**PRIM. REFUSE MEDIA**	**ID:**	**PRIM. REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,579	**Lab #:**	32,579
Weights	Grams	**Weights**	Grams
Flask	67.7089	**Flask**	63.7009
Flask, Non-Mag, Mags	82.8239	**Flask, Non-Mag, Mags**	78.8122
Flask + Mags	81.2721	**Flask + Mags**	77.2632
% Mags:	89.73%	**% Mags:**	89.75%

RUN AVG:	**89.74%**

ID:	**PRIM. REFUSE MEDIA**	**ID:**	**PRIM. REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,580	**Lab #:**	32,580
Weights	Grams	**Weights**	Grams
Flask	65.2324	**Flask**	68.7357
Flask, Non-Mag, Mags	80.8658	**Flask, Non-Mag, Mags**	83.8916
Flask + Mags	79.2546	**Flask + Mags**	82.3055
% Mags:	89.69%	**% Mags:**	89.53%

RUN AVG:	**89.61%**
TOT AVG:	**89.68%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 5 of 7

Plant:	**CIRCUIT B1**		
ID:	**SEC. FEED MEDIA**	**ID:**	**SEC. FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,581	**Lab #:**	32,581
Weights	Grams	**Weights**	Grams
Flask	64.7015	**Flask**	68.6489
Flask, Non-Mag, Mags	79.8134	**Flask, Non-Mag, Mags**	83.8197
Flask + Mags	76.8810	**Flask + Mags**	80.8218
% Mags:	80.60%	**% Mags:**	80.24%

RUN AVG:	**80.42%**

ID:	**SEC. FEED MEDIA**	**ID:**	**SEC. FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,582	**Lab #:**	32,582
Weights	Grams	**Weights**	Grams
Flask	67.6908	**Flask**	66.7684
Flask, Non-Mag, Mags	82.8072	**Flask, Non-Mag, Mags**	81.8112
Flask + Mags	79.8778	**Flask + Mags**	78.8878
% Mags:	80.62%	**% Mags:**	80.57%

RUN AVG:	**80.59%**

TOT AVG:	**80.51%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 6 of 7

Plant:	**CIRCUIT B1**		
ID:	**SEC. CLEAN COAL MEDIA**	**ID:**	**SEC. CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,583	**Lab #:**	32,583
Weights	Grams	**Weights**	Grams
Flask	78.4496	**Flask**	65.6639
Flask, Non-Mag, Mags	93.8425	**Flask, Non-Mag, Mags**	80.8062
Flask + Mags	89.3403	**Flask + Mags**	76.3321
% Mags:	70.75%	**% Mags:**	70.45%

RUN AVG:	**70.60%**

ID:	**SEC. CLEAN COAL MEDIA**	**ID:**	**SEC. CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,584	**Lab #:**	32,584
Weights	Grams	**Weights**	Grams
Flask	63.7204	**Flask**	77.6111
Flask, Non-Mag, Mags	78.8205	**Flask, Non-Mag, Mags**	92.8314
Flask + Mags	74.3527	**Flask + Mags**	88.3377
% Mags:	70.41%	**% Mags:**	70.48%

RUN AVG:	**70.44%**

TOT AVG:	**70.52%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 7 of 7

Plant:	**CIRCUIT B1**		
ID:	**SEC. REFUSE (MIDDS) MEDIA**	**ID:**	**SEC. REFUSE (MIDDS) MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,585	**Lab #:**	32,585
Weights	Grams	**Weights**	Grams
Flask	68.0539	**Flask**	69.5288
Flask, Non-Mag, Mags	83.8199	**Flask, Non-Mag, Mags**	84.8191
Flask + Mags	82.1810	**Flask + Mags**	83.2382
% Mags:	89.60%	**% Mags:**	89.66%

RUN AVG:	**89.63%**

ID:	**SEC. REFUSE (MIDDS) MEDIA**	**ID:**	**SEC. REFUSE (MIDDS) MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,586	**Lab #:**	32,586
Weights	Grams	**Weights**	Grams
Flask	65.9100	**Flask**	81.6971
Flask, Non-Mag, Mags	80.8343	**Flask, Non-Mag, Mags**	96.8033
Flask + Mags	79.3088	**Flask + Mags**	95.1262
% Mags:	89.78%	**% Mags:**	88.90%

RUN AVG:	**89.34%**
TOT AVG:	**89.49%**

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
PRIM. FEED	#1	1 OF 2	19,956.1	929.5	18,561.2	19,026.6	17,631.7	7.33%
PRIM. FEED	#1	2 OF 2	19,944.7	1,020.7	18,309.4	18,924.0	17,288.7	8.64%
SUBTOTAL FEED	#1	2	39,900.8	1,950.2	36,870.6	37,950.6	34,920.4	7.98%
PRIM. FEED	#2	1 OF 2	19,849.0	823.4	18,216.5	19,025.6	17,393.1	8.58%
PRIM. FEED	#2	2 OF 2	20,265.0	815.3	18,407.6	19,449.7	17,592.3	9.55%
SUBTOTAL FEED	#2	2	40,114.0	1,638.7	36,624.1	38,475.3	34,985.4	9.07%
TOTAL FEED	#2	4	80,014.8	3,588.9	73,494.7	76,425.9	69,905.8	8.53%
PRIM. CLEAN COAL	#1	1 OF 2	13,563.3	1,024.0	12,734.1	12,539.3	11,710.1	6.61%
PRIM. CLEAN COAL	#1	2 OF 2	10,164.7	1,006.6	9,545.4	9,158.1	8,538.8	6.76%
SUBTOTAL CC	#1	2	23,728.0	2,030.6	22,279.5	21,697.4	20,248.9	6.68%
PRIM. CLEAN COAL	#2	1 OF 2	16,997.9	1,013.5	15,779.6	15,984.4	14,766.1	7.62%
PRIM. CLEAN COAL	#2	2 OF 2	13,385.1	964.2	12,339.6	12,420.9	11,375.4	8.42%
SUBTOTAL CC	#2	2	30,383.0	1,977.7	28,119.2	28,405.3	26,141.5	7.97%
TOTAL PRIM. CC	#2	4	54,111.0	4,008.3	50,398.7	50,102.7	46,390.4	7.41%
PRIM. REFUSE	#1	1 OF 4	20,974.2	1,048.1	20,464.2	19,926.1	19,416.1	2.56%
PRIM. REFUSE	#1	2 OF 4	24,292.1	940.6	23,780.6	23,351.5	22,840.0	2.19%
PRIM. REFUSE	#1	3 OF 4	24,445.6	970.4	23,942.4	23,475.2	22,972.0	2.14%
PRIM. REFUSE	#1	4 OF 4	24,428.8	930.0	23,910.0	23,498.8	22,980.0	2.21%
TOTAL PRIM. REF	#1	4	94,140.7	3,889.1	92,097.2	90,251.6	88,208.1	2.26%
SEC. CLEAN COAL	#1	1 OF 4	12,553.8	811.8	11,943.4	11,742.0	11,131.6	5.20%
SEC. CLEAN COAL	#1	2 OF 4	12,998.0	807.9	12,418.4	12,190.1	11,610.5	4.75%
SEC. CLEAN COAL	#1	3 OF 4	12,227.0	802.8	11,689.6	11,424.2	10,886.8	4.70%
SEC. CLEAN COAL	#1	4 OF 4	10,928.7	805.4	10,471.9	10,123.3	9,666.5	4.51%
TOTAL SEC. CC	#1	4	48,707.5	3,227.9	46,523.3	45,479.6	43,295.4	4.80%
SEC. MIDDS	#1	1 OF 4	13,824.2	801.2	13,099.3	13,023.0	12,298.1	5.57%
SEC. MIDDS	#1	2 OF 4	14,630.1	807.9	13,975.7	13,822.2	13,167.8	4.73%
SEC. MIDDS	#1	3 OF 4	12,992.1	800.2	12,436.5	12,191.9	11,636.3	4.56%
SEC. MIDDS	#1	4 OF 4	9,414.7	805.7	9,036.0	8,609.0	8,230.3	4.40%
TOTAL SEC. MIDDS	#1	4	50,861.1	3,215.0	48,547.5	47,646.1	45,332.5	4.86%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST
MEDIA SAMPLES

PRIMARY FEED MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	8,484.1	TARE WT.	999.7
SOLIDS WT.	3,792.9	% SOLIDS	50.68%
LAB NO.	SIZE	WT (Grams)	WT %
29,989	+ 25M	49.1	1.29%
29,990	25M x 0	3,743.8	98.71%
	Totals	3,792.9	100.00%

PRIM. CLEAN COAL #1 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,912.3	TARE WT.	799.2
SOLIDS WT.	1,816.3	% SOLIDS	44.16%
LAB NO.	SIZE	WT (Grams)	WT %
29,991	+ 25M	19.0	1.05%
29,992	25M x 0	1,797.3	98.95%
	Totals	1,816.3	100.00%

PRIM. CLEAN COAL #2 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	3,828.7	TARE WT.	803.6
SOLIDS WT.	1,367.4	% SOLIDS	45.20%
LAB NO.	SIZE	WT (Grams)	WT %
29,993	+ 25M	10.6	0.78%
29,994	25M x 0	1,356.8	99.22%
	Totals	1,367.4	100.00%

PRIM. REFUSE MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	6,075.9	TARE WT.	816.1
SOLIDS WT.	3,033.0	% SOLIDS	57.66%
LAB NO.	SIZE	WT (Grams)	WT %
29,995	+ 25M	16.8	0.55%
29,996	25M x 0	3,016.2	99.45%
	Totals	3,033.0	100.00%

SEC. FEED MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	6,016.7	TARE WT.	1,000.7
SOLIDS WT.	1,752.1	% SOLIDS	34.93%
LAB NO.	SIZE	WT (Grams)	WT %
29,997	+ 25M	25.0	1.43%
29,998	25M x 0	1,727.1	98.57%
	Totals	1,752.1	100.00%

SEC. CLEAN COAL MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,356.1	TARE WT.	805.4
SOLIDS WT.	933.2	% SOLIDS	26.28%
LAB NO.	SIZE	WT (Grams)	WT %
29,999	+ 25M	20.5	2.20%
30,000	25M x 0	912.7	97.80%
	Totals	933.2	100.00%

SEC. REFUSE (MIDDS) MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	5,842.2	TARE WT.	804.7
SOLIDS WT.	2,319.8	% SOLIDS	46.05%
LAB NO.	SIZE	WT (Grams)	WT %
30,001	+ 25M	9.8	0.42%
30,002	25M x 0	2,310.0	99.58%
	Totals	2,319.8	100.00%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC FEED SAMPLE - SCREEN ANALYSIS

Combine all four (4) feed samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	69,905.8	Grams or	154.116	Lbs
START WEIGHT - REWEIGH:	154.40	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
30,003	51.74

Screen Analysis (Using 7 Containers) 136.2 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
30,004	+ 16mm	23,450.7	Grams	38.15%	70.10
30,005	*16 x 8mm*	12,519.2	Grams	20.37%	54.61
30,006	8 x 4mm	8,346.1	Grams	13.58%	44.05
30,007	4mm x 0	17,145.8	Grams	27.90%	30.70
Totals	**+16mm x 0**	**61,461.8**	**Grams**	**100.00%**	**52.42**

Total Wt	61,461.8	Grams	100.00%	or	135.5	Lbs
Screen Loss	317.5	Grams		or	0.51	%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	9,347.8	Lbs	Grams		
LOSS:	2.3	Grams	or	0.02	%

LAB #	GRAVITY	WT	Units	WT%
31,331	1.400	2,662.3	Grams	28.49%
31,332	1.500	433.2	Grams	4.64%
31,333	1.600	236.6	Grams	2.53%
31,334	1.650	63.4	Grams	0.68%
31,335	1.700	67.1	Grams	0.72%
31,336	1.750	100.0	Grams	1.07%
31,337	1.800	74.3	Grams	0.80%
31,338	1.850	118.6	Grams	1.27%
31,339	1.900	99.6	Grams	1.07%
31,340	2.000	211.0	Grams	2.26%
31,341	SINK	5,279.4	Grams	56.49%
TOTAL		9,345.5	Grams	100.00%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	6,329.1	Lbs	Grams		
LOSS:	30.1	Grams	or	0.48	%

LAB #	GRAVITY	WT	Units	WT%
31,342	1.400	2,697.7	Grams	42.83%
31,343	1.500	209.7	Grams	3.33%
31,344	1.600	99.4	Grams	1.58%
31,345	1.650	44.1	Grams	0.70%
31,346	1.700	38.1	Grams	0.60%
31,347	1.750	37.2	Grams	0.59%
31,348	1.800	36.8	Grams	0.58%
31,349	1.850	46.1	Grams	0.73%
31,350	1.900	47.3	Grams	0.75%
31,351	2.000	135.1	Grams	2.14%
31,352	SINK	2,907.5	Grams	46.16%
TOTAL		6,299.0	Grams	100.00%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all four (4) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT: 46,390.4 Grams or 102.273 Lbs

START WEIGHT - REWEIGH: 102.50 Lbs

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
32,587	9.67

Screen Analysis (Using 7 Containers) 89.8 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
32,588	+ 16mm	15,013.9	Grams	36.94%	13.03
32,589	*16 x 8mm*	14,877.8	Grams	36.61%	8.59
32,590	8 x 4mm	7,166.8	Grams	17.63%	5.89
32,591	4mm x 0	3,583.4	Grams	8.82%	4.98
Totals	+16mm x 0	40,641.9	Grams	100.00%	9.44

Total Wt	40,641.9	Grams	100.00%	or	89.6	Lbs
Screen Loss	90.7	Grams		or	0.22	%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	11,148.6	Grams			
LOSS:	34.5	Grams	or	0.31	%

LAB #	GRAVITY	WT	Units	WT%
33,380	1.300	6,811.8	Grams	61.290%
33,381	1.325	863.5	Grams	7.769%
33,382	1.350	462.9	Grams	4.165%
33,383	1.375	317.0	Grams	2.852%
33,384	1.400	243.1	Grams	2.187%
33,385	1.425	209.7	Grams	1.887%
33,386	1.450	311.1	Grams	2.799%
33,387	1.500	677.2	Grams	6.093%
33,388	1.550	388.8	Grams	3.498%
33,389	1.600	262.2	Grams	2.359%
33,390	1.650	234.3	Grams	2.108%
33,391	1.700	215.4	Grams	1.938%
33,392	1.750	111.5	Grams	1.003%
33,393	1.800	4.7	Grams	0.042%
	1.850	0.0	Grams	0.000%
33,394	1.900	0.5	Grams	0.004%
	2.000	0.0	Grams	0.000%
33,395	SINK	0.4	Grams	0.004%
TOTAL		11,114.1	Grams	100.000%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	5,300.8	Grams			
LOSS:	11.6	Grams	or	0.22	%

LAB #	GRAVITY	WT	Units	WT%
33,728	1.300	3,656.8	Grams	69.137%
33,729	1.325	433.3	Grams	8.192%
33,730	1.350	292.6	Grams	5.532%
33,731	1.375	141.9	Grams	2.683%
33,732	1.400	110.3	Grams	2.085%
33,733	1.425	83.8	Grams	1.584%
33,734	1.450	88.5	Grams	1.673%
33,735	1.500	166.6	Grams	3.150%
33,736	1.550	106.2	Grams	2.008%
33,737	1.600	71.2	Grams	1.346%
33,738	1.650	54.7	Grams	1.034%
33,739	1.700	50.0	Grams	0.945%
33,740	1.750	26.3	Grams	0.497%
33,741	1.800	5.0	Grams	0.095%
33,742	1.850	0.5	Grams	0.009%
33,743	1.900	0.3	Grams	0.006%
33,744	2.000	0.4	Grams	0.008%
33,745	SINK	0.8	Grams	0.015%
TOTAL		5,289.2	Grams	100.000%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all four (4) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	88,208.1	Grams or	194.466	Lbs
START WEIGHT - REWEIGH:	186.80	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
33,815	83.84

Screen Analysis (Using 7 Containers) 163.5 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
33,816	+ 16mm	51,891.0	Grams	70.23%	84.07
33,817	*16 x 8mm*	17,871.5	Grams	24.19%	83.94
33,818	8 x 4mm	2,661.1	Grams	3.60%	86.78
33,819	4mm x 0	1,466.1	Grams	1.98%	81.18
Totals	+16mm x 0	73,889.7	Grams	100.00%	84.08

Total Wt	73,889.7	Grams	100.00%	or	162.9	Lbs
Screen Loss	272.6	Grams		or	0.37	%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	13,415.6	Grams			
LOSS:	5.2	Grams	or	0.04	%

LAB #	GRAVITY	WT	Units	WT%
34,383	1.400	0.4	Grams	0.003%
	1.500	0.0	Grams	0.000%
34,384	1.600	1.5	Grams	0.011%
34,385	1.650	2.1	Grams	0.016%
34,386	1.700	21.4	Grams	0.160%
34,387	1.750	68.5	Grams	0.511%
34,388	1.800	110.8	Grams	0.826%
34,389	1.850	167.4	Grams	1.248%
34,390	1.900	174.7	Grams	1.303%
34,391	2.000	369.4	Grams	2.755%
34,392	SINK	12,494.2	Grams	93.168%
TOTAL		13,410.4		100.000%

CIRCUIT B1 - PRIMARY HMC PERFORMANCE TEST

PRIMARY HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	1,973.1	Grams			
LOSS:	6.9	Grams	or	0.35	%

LAB #	GRAVITY	WT	Units	WT%
34,396	1.400	0.9	Grams	0.046%
34,397	1.500	0.4	Grams	0.020%
34,398	1.600	0.5	Grams	0.025%
34,399	1.650	0.6	Grams	0.031%
34,400	1.700	2.2	Grams	0.112%
34,401	1.750	6.9	Grams	0.351%
34,402	1.800	9.4	Grams	0.478%
34,403	1.850	13.9	Grams	0.707%
34,404	1.900	14.0	Grams	0.712%
34,405	2.000	29.4	Grams	1.495%
34,406	SINK	1,888.0	Grams	96.023%
TOTAL		1,966.2		100.000%

Test Description: CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

Feed Coal Type: Sewell

	Body	Vortex	Apex
Manufacturer:	Krebs	Krebs	Krebs
Diameter (Inch):	26	8	7.03
Wear Condition:	Good	Good	Excellen
Part Alignment:			Good

Plant Feed Rate (tph): 595
Circuit Feed Rate(tph): 85.5

Inlet Pressure (psi): 15.5
Gauge Position (inch): -28
Head (Diameters): 12.0
Magnetite Grade: B

Tracer Size (mm): 32
Tracer Shape: Cubes

Weighting (Y/N)? N
SG Cutpoint (SG50) 1.369
Probable Error (Ep): 0.010
Low SG Offset: 0.000

Tracer SG	Tracer in Feed	Overflow (Clean Coal)							Underflow (Refuse)							Tracers Collected	Tracers Lost	Refuse Partition	Fitted Partition	Weight Factor	Weighted Error
		A	B	C	D	E	F	Sum	A	B	C	D	E	F	Sum						
1.32	40	36						36	2						2	0.95	0.05	0.05	0.00	0.10	0.00
1.36	40	29						29	10						10	0.98	0.03	0.26	0.26	0.26	0.00
1.40	40	1						1	39						39	1.00	0.00	0.98	0.97	0.10	0.00
1.42	40	0						0	40						40	1.00	0.00	1.00	1.00	0.10	0.00
1.52	40	0						0	39						39	0.98	0.03	1.00	1.00	0.10	0.00
Known Dropped		0						0	0						0					Total WSSQ:	0.00

Description: CIRCUIT B2 - SECONDARY COARSE COAL HI

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections: Real World	Ep Corrections: O&M Factors	Ep Corrections: Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1	0.008	0.010
16	8	11.31	0.003	1.5	1	0.008	0.013
8	4	5.66	0.007	1.5	1	0.008	0.018
4	2	2.83	0.013	1.5	1	0.008	0.028
2	1	1.41	0.026	1.5	1	0.008	0.047
1	0.5	0.71	0.052	1.5	1	0.008	0.086

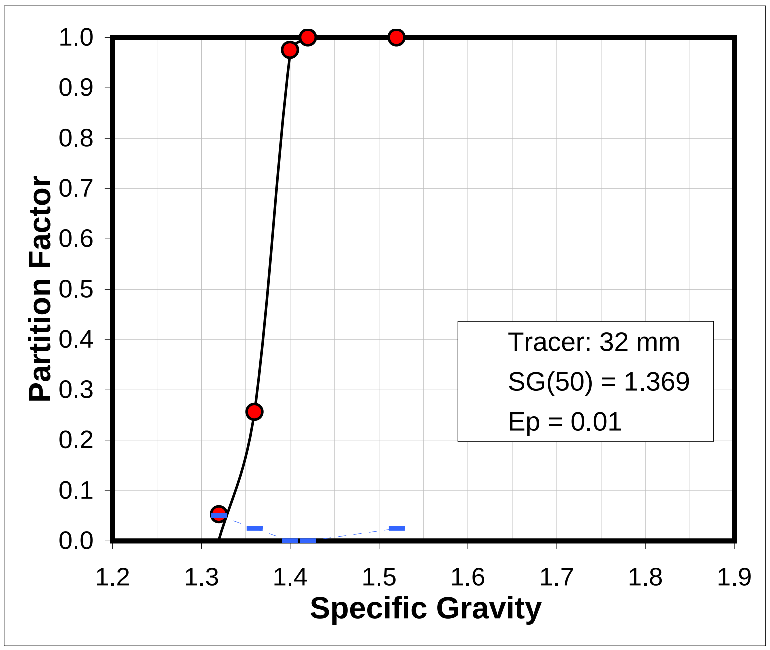
Comments:

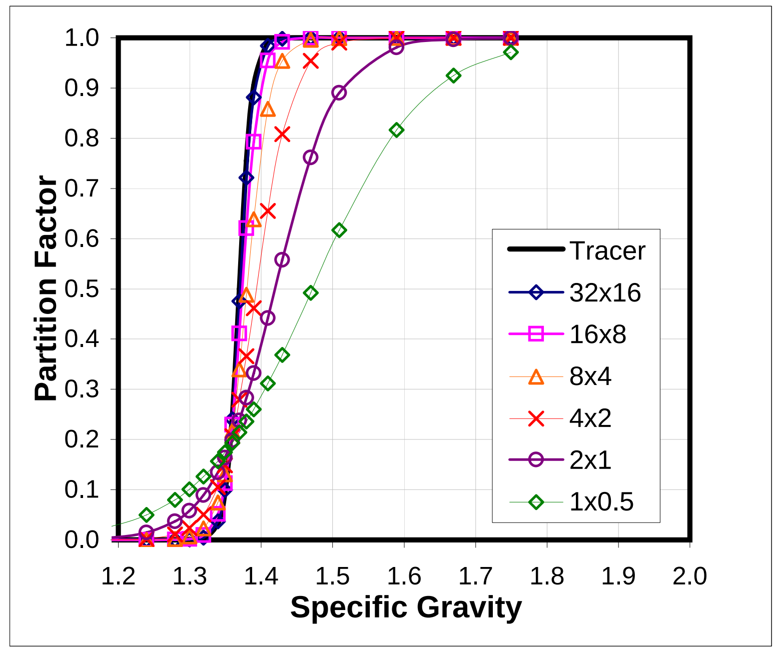
	SG	Split
O/F:	1.200	0.813
U/F:	1.520	0.188
Feed:	1.260	1.000

	SG	Split
Pivot:	1.356	0.188
O/F-U/F	0.32	

Obs.	Marcy Scale SG: Feed	Marcy Scale SG: O/F	Marcy Scale SG: U/F
1	1.26	1.2	1.52
2			
3			
4			
5			
Avg.	1.260	1.200	1.520

Size	32	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.369	1.370	1.374	1.380	1.393	1.419	1.472
Ep	0.010	0.010	0.013	0.018	0.028	0.047	0.086
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





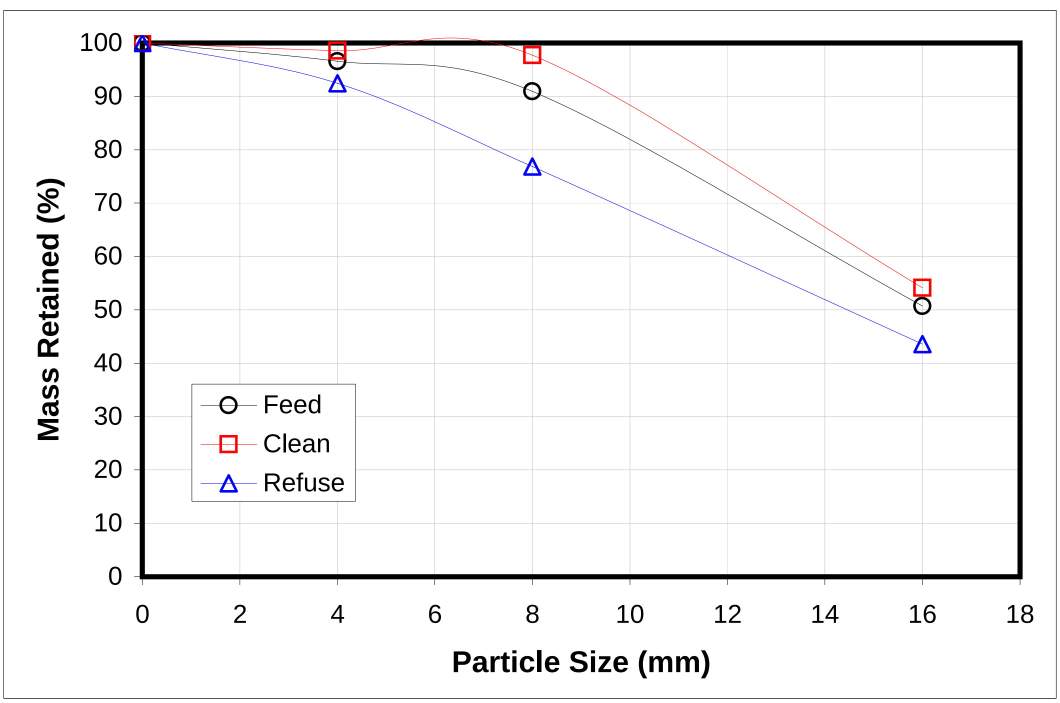
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	294.0		Clean Yield (%):	67.59
Refuse Rate (t/hr):	141.0		Refuse Yield (%):	32.41
Feed Rate (t/hr):	435.0			

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	54.13	2.62	43.59	28.30	50.72	9.77
16	8	11.31	43.59	2.72	33.29	21.31	40.26	7.70
8	4	5.66	0.84	2.40	15.56	19.14	5.61	17.44
4	0	0.00	1.43	2.94	7.55	15.28	3.41	11.78
		Totals	100.00	2.67	100.00	23.56	100.00	9.44

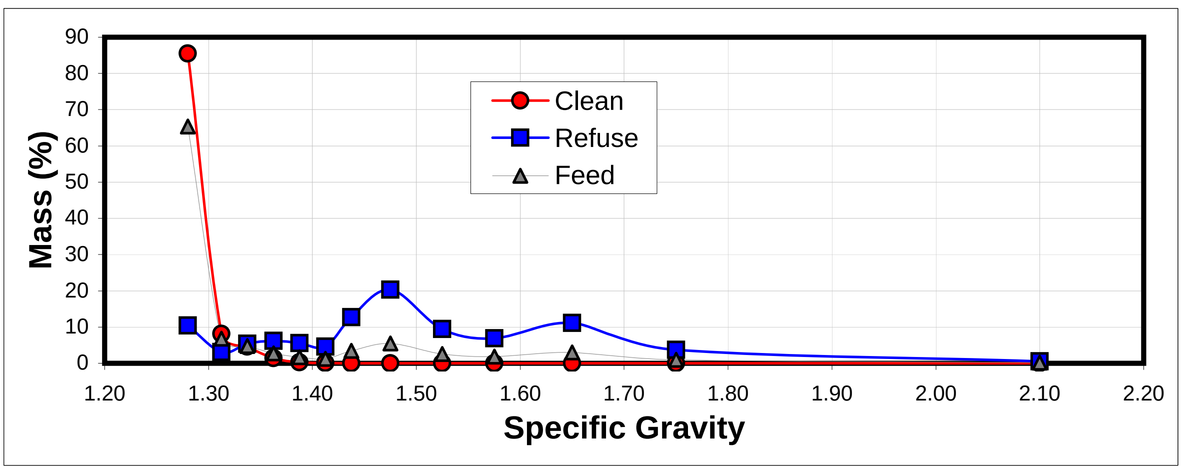
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	72.14	27.86	100.00	54.13	43.59	50.72
16	8	11.31	73.19	26.81	100.00	97.73	76.89	90.97
8	4	5.66	10.15	89.85	100.00	98.57	92.45	96.59
4	0	0.00	28.32	71.68	100.00	100.00	100.00	100.00
		Totals	67.59	32.41	100.00			

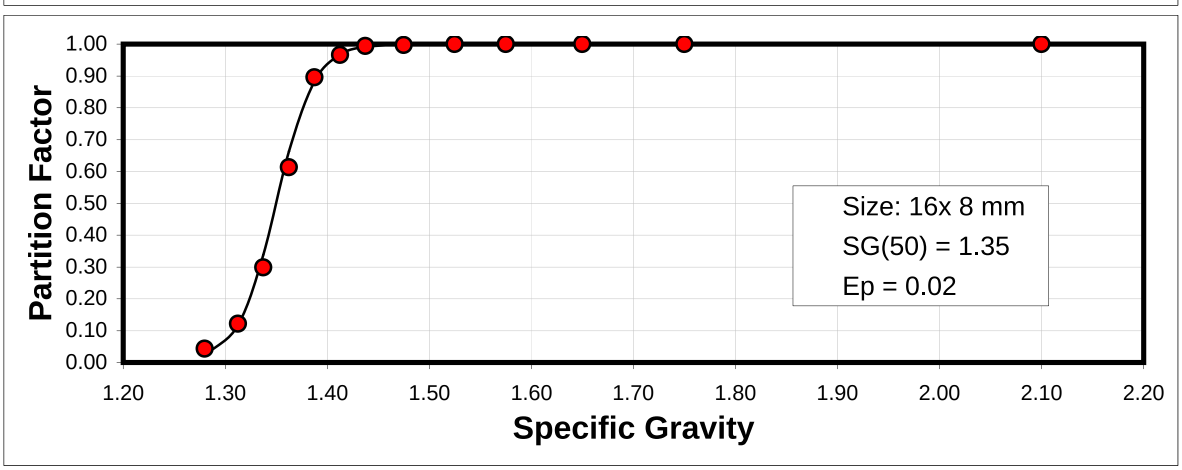


Circuit:	CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT
Size:	16x 8 mm

Clean Yield (%)	73.19	SG Cutpoint (SG50)	1.350	Weighting (Y/N)?	Y
Refuse Yield (%)	26.81	Probable Error (Ep):	0.020	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	85.453	10.45	65.35	0.04	0.02	0.10	0.04
1.300	1.325	1.313	8.156	3.08	6.80	0.12	0.12	0.12	0.00
1.325	1.350	1.338	4.609	5.36	4.81	0.30	0.34	0.30	0.02
1.350	1.375	1.363	1.429	6.18	2.70	0.61	0.66	0.39	0.02
1.375	1.400	1.388	0.239	5.56	1.67	0.90	0.88	0.10	0.01
1.400	1.425	1.413	0.060	4.60	1.28	0.97	0.97	0.10	0.00
1.425	1.450	1.438	0.028	12.69	3.42	0.99	0.99	0.10	0.00
1.450	1.500	1.475	0.026	20.29	5.46	1.00	1.00	0.10	0.00
1.500	1.550	1.525	0.000	9.49	2.54	1.00	1.00	0.10	0.00
1.550	1.600	1.575	0.000	6.92	1.86	1.00	1.00	0.10	0.00
1.600	1.700	1.650	0.000	11.14	2.99	1.00	1.00	0.10	0.00
1.700	1.800	1.750	0.000	3.74	1.00	1.00	1.00	0.10	0.00
1.800	2.400	2.100	0.000	0.50	0.13	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.09

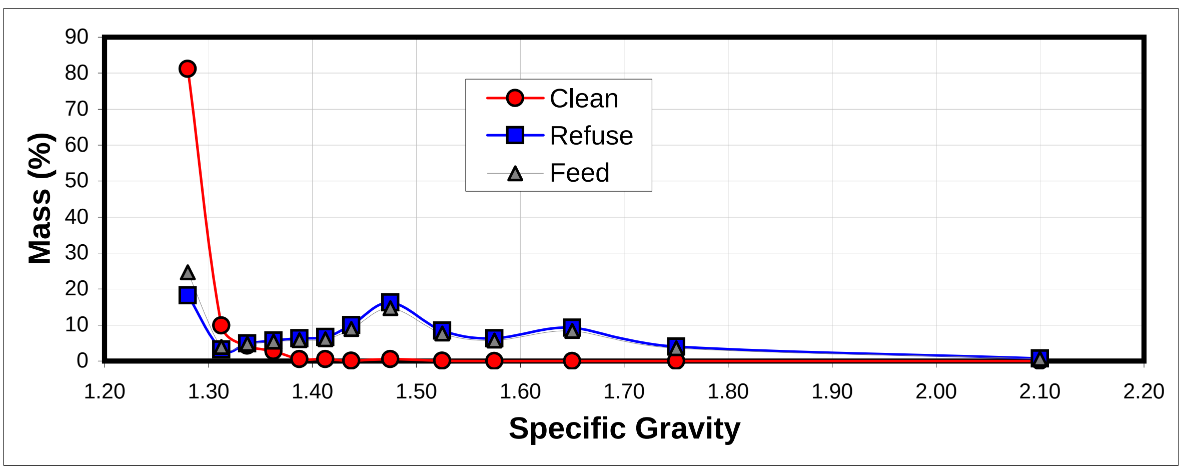


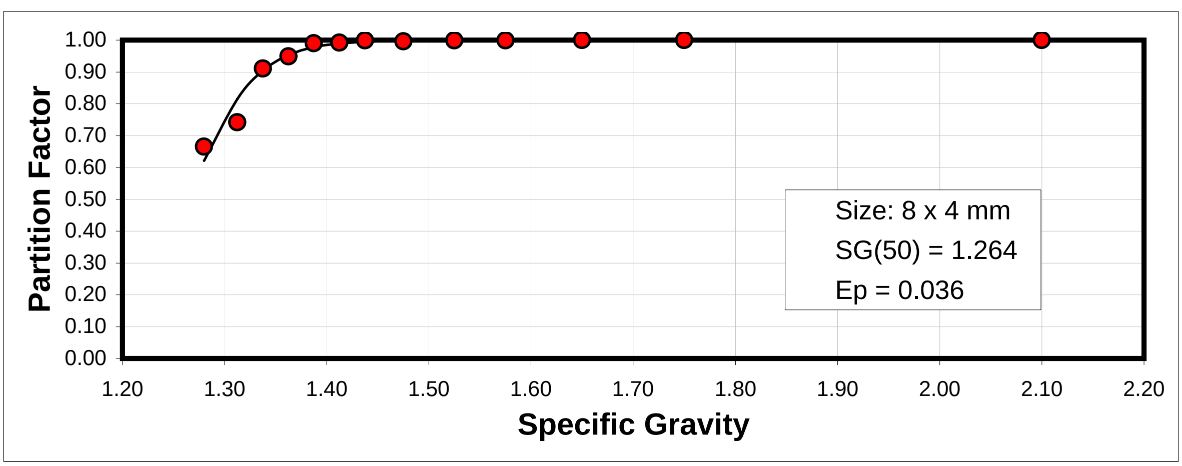


Circuit:	CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT
Size:	8 x 4 mm

Clean Yield (%)	10.15	SG Cutpoint (SG50)	1.264	Weighting (Y/N)?	Y
Refuse Yield (%)	89.85	Probable Error (Ep):	0.036	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	81.17	18.24	24.63	0.67	0.62	0.33	0.02
1.300	1.325	1.313	9.91	3.22	3.90	0.74	0.82	0.26	0.08
1.325	1.350	1.338	4.25	4.92	4.85	0.91	0.90	0.10	0.00
1.350	1.375	1.363	2.73	5.69	5.39	0.95	0.95	0.10	0.00
1.375	1.400	1.388	0.58	6.34	5.75	0.99	0.98	0.10	0.02
1.400	1.425	1.413	0.50	6.64	6.02	0.99	0.99	0.10	0.00
1.425	1.450	1.438	0.08	9.94	8.94	1.00	0.99	0.10	0.00
1.450	1.500	1.475	0.54	16.30	14.70	1.00	1.00	0.10	0.00
1.500	1.550	1.525	0.08	8.47	7.62	1.00	1.00	0.10	0.00
1.550	1.600	1.575	0.04	6.29	5.65	1.00	1.00	0.10	0.00
1.600	1.700	1.650	0.00	9.27	8.33	1.00	1.00	0.10	0.00
1.700	1.800	1.750	0.00	3.98	3.58	1.00	1.00	0.10	0.00
1.800	2.400	2.100	0.00	0.70	0.63	1.00	1.00	0.10	0.00
		Totals	99.88	100.00	99.99			WSSQ:	0.12

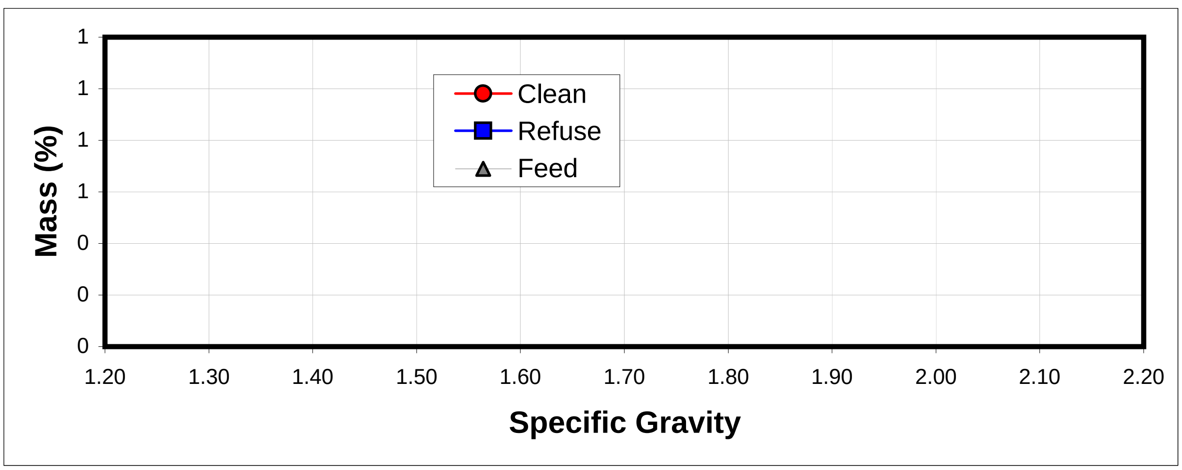


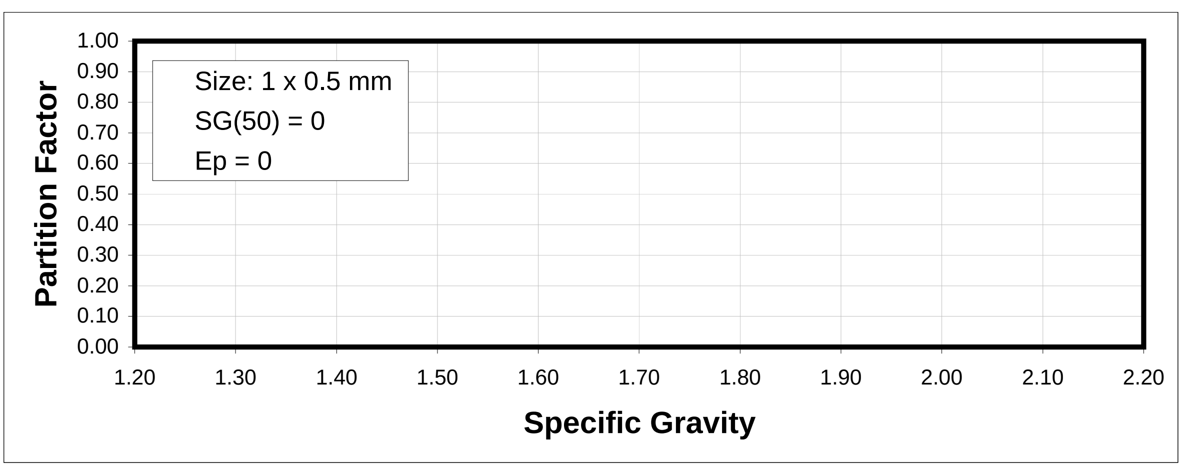


Circuit: CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT
Size: 1 x 0.5 mm

Clean Yield (%)	0.00	SG Cutpoint (SG50):		Weighting (Y/N)?	
Refuse Yield (%)	100.00	Probable Error (Ep):		Low SG Offset:	

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330							
1.400	1.500	1.450							
1.500	1.600	1.550							
1.600	1.650	1.625							
1.650	1.700	1.675							
1.700	1.750	1.725							
1.750	1.800	1.775							
1.800	1.850	1.825							
1.850	1.900	1.875							
1.900	2.000	1.950							
2.000	2.400	2.200							
		Totals	0.00	0.00	0.00			WSSQ:	0.00

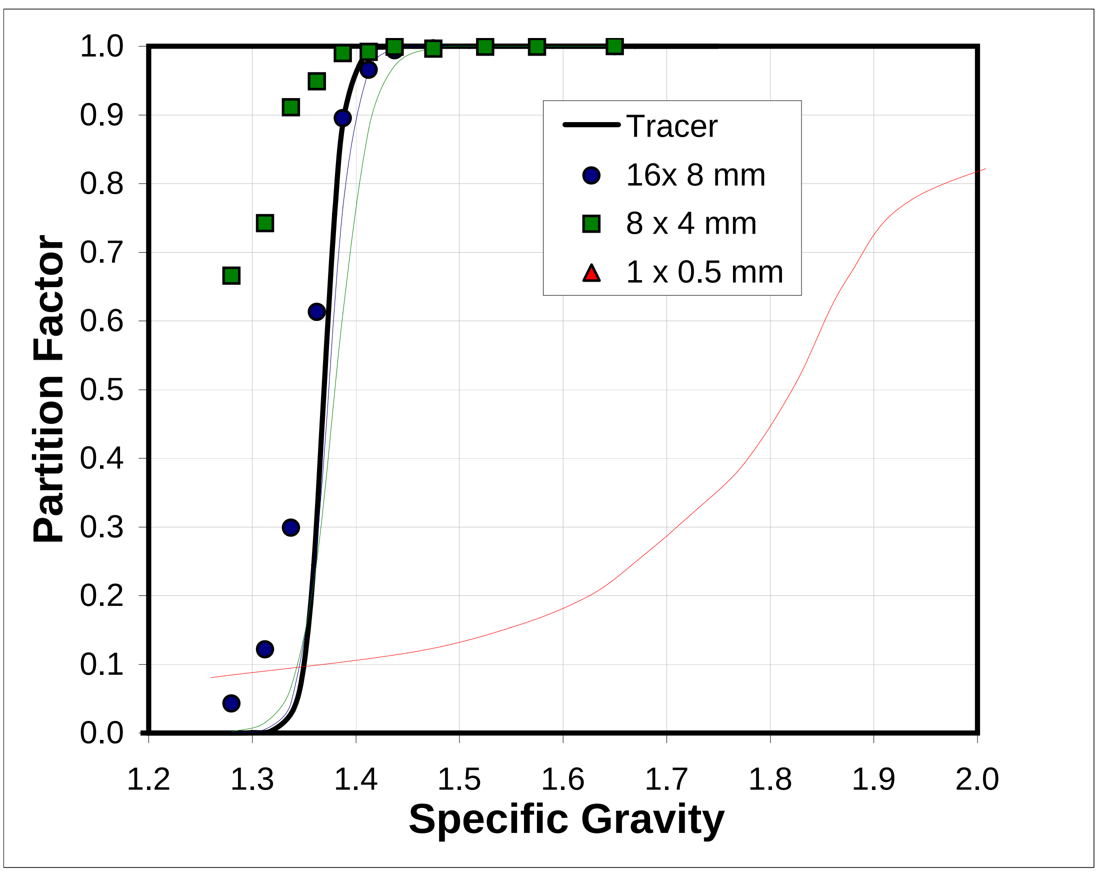


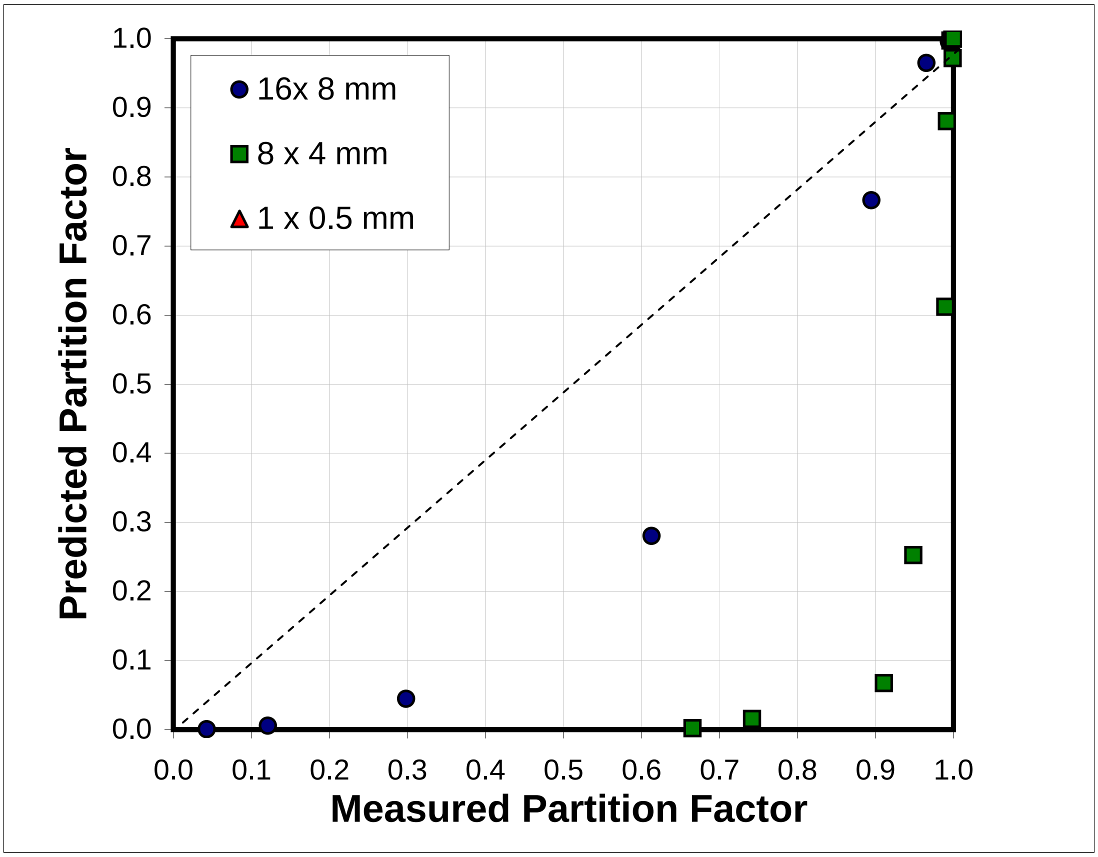


Circuit: CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

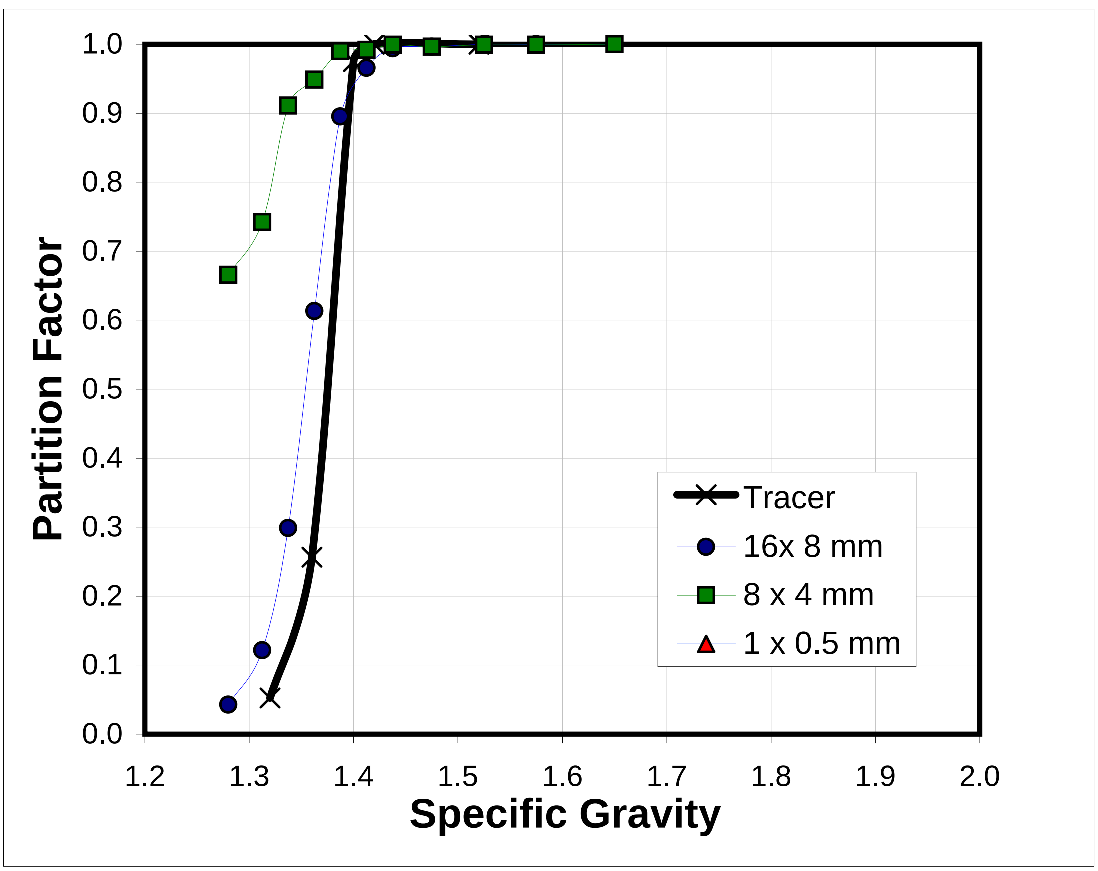
	Measured 16x 8 mm	Predicted 16x 8 mm		Measured 8 x 4 mm	Predicted 8 x 4 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.350	1.374	SG(50):	1.264	1.380	SG(50):	0.000	1.472
Ep:	0.020	0.013	Ep:	0.036	0.018	Ep:	0.000	0.086
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16x 8 mm	Predicted 16x 8 mm	SG	Measured 8 x 4 mm	Predicted 8 x 4 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.28	0.04	0.000	1.28	0.67	0.002	1.26		0.080
1.31	0.12	0.005	1.31	0.74	0.015	1.45		0.117
1.34	0.30	0.044	1.34	0.91	0.067	1.55		0.154
1.36	0.61	0.280	1.36	0.95	0.252	1.63		0.200
1.39	0.90	0.766	1.39	0.99	0.612	1.68		0.255
1.41	0.97	0.965	1.41	0.99	0.881	1.73		0.320
1.44	0.99	0.996	1.44	1.00	0.972	1.78		0.393
1.48	1.00	1.000	1.48	1.00	0.997	1.83		0.510
1.53	1.00	1.000	1.53	1.00	1.000	1.88		0.663
1.58	1.00	1.000	1.58	1.00	1.000	1.95		0.788
1.65	1.00	1.000	1.65	1.00	1.000	2.20		0.906





Predicted Partition Factor
Measured Partition Factor
16x 8 mm
8 x 4 mm
1 x 0.5 mm



Partition Factor
Specific Gravity
Tracer
16x 8 mm
8 x 4 mm
1 x 0.5 mm

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC FEED COAL SAMPLE - SCREEN ANALYSIS

Combine all four (4) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT: 46,390.4 Grams or 102.273 Lbs

START WEIGHT - REWEIGH: 102.50 Lbs

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
32,587	9.67

Screen Analysis (Using 7 Containers) 89.8 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
32,588	+ 16mm	15,013.9	Grams	36.94%	13.03
32,589	*16 x 8mm*	14,877.8	Grams	36.61%	8.59
32,590	8 x 4mm	7,166.8	Grams	17.63%	5.89
32,591	4mm x 0	3,583.4	Grams	8.82%	4.98
Totals	+16mm x 0	40,641.9	Grams	100.00%	9.44

Total Wt	40,641.9	Grams	100.00%	or	89.6	Lbs
Screen Loss	90.7	Grams		or	0.22	%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC FEED COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	11,148.6	Grams			
LOSS:	34.5	Grams	or	0.31	%

LAB #	GRAVITY	WT	Units	WT%
33,380	1.300	6,811.8	Grams	61.290%
33,381	1.325	863.5	Grams	7.769%
33,382	1.350	462.9	Grams	4.165%
33,383	1.375	317.0	Grams	2.852%
33,384	1.400	243.1	Grams	2.187%
33,385	1.425	209.7	Grams	1.887%
33,386	1.450	311.1	Grams	2.799%
33,387	1.500	677.2	Grams	6.093%
33,388	1.550	388.8	Grams	3.498%
33,389	1.600	262.2	Grams	2.359%
33,390	1.650	234.3	Grams	2.108%
33,391	1.700	215.4	Grams	1.938%
33,392	1.750	111.5	Grams	1.003%
33,393	1.800	4.7	Grams	0.042%
	1.850	0.0	Grams	0.000%
33,394	1.900	0.5	Grams	0.004%
	2.000	0.0	Grams	0.000%
33,395	SINK	0.4	Grams	0.004%
TOTAL		11,114.1	Grams	100.000%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC FEED COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	5,300.8	Grams			
LOSS:	11.6	Grams	or	0.22	%

LAB #	GRAVITY	WT	Units	WT%
33,728	1.300	3,656.8	Grams	69.137%
33,729	1.325	433.3	Grams	8.192%
33,730	1.350	292.6	Grams	5.532%
33,731	1.375	141.9	Grams	2.683%
33,732	1.400	110.3	Grams	2.085%
33,733	1.425	83.8	Grams	1.584%
33,734	1.450	88.5	Grams	1.673%
33,735	1.500	166.6	Grams	3.150%
33,736	1.550	106.2	Grams	2.008%
33,737	1.600	71.2	Grams	1.346%
33,738	1.650	54.7	Grams	1.034%
33,739	1.700	50.0	Grams	0.945%
33,740	1.750	26.3	Grams	0.497%
33,741	1.800	5.0	Grams	0.095%
33,742	1.850	0.5	Grams	0.009%
33,743	1.900	0.3	Grams	0.006%
33,744	2.000	0.4	Grams	0.008%
33,745	SINK	0.8	Grams	0.015%
TOTAL		5,289.2	Grams	100.000%

PLANT B - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 7

Plant:	**PLANT B**		
ID:	**PRIMARY FEED MEDIA**	**ID:**	**PRIMARY FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,573	**Lab #:**	32,573
Weights	Grams	**Weights**	Grams
Flask	68.3073	**Flask**	63.5024
Flask, Non-Mag, Mags	83.8126	**Flask, Non-Mag, Mags**	78.8842
Flask + Mags	81.4310	**Flask + Mags**	76.4946
% Mags:	84.64%	**% Mags:**	84.46%

RUN AVG:	**84.55%**

ID:	**PRIMARY FEED MEDIA**	**ID:**	**PRIMARY FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,574	**Lab #:**	32,574
Weights	Grams	**Weights**	Grams
Flask	67.1983	**Flask**	64.6442
Flask, Non-Mag, Mags	82.8569	**Flask, Non-Mag, Mags**	79.8407
Flask + Mags	80.3074	**Flask + Mags**	77.3384
% Mags:	83.72%	**% Mags:**	83.53%

RUN AVG:	**83.63%**
TOT AVG:	**84.09%**

PLANT B - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 2 of 7

Plant:	**PLANT B**		
ID:	**PRIM. CLEAN COAL #1 MEDIA**	**ID:**	**PRIM. CLEAN COAL #1 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,575	**Lab #:**	32,575
Weights	Grams	**Weights**	Grams
Flask	67.4813	**Flask**	66.3542
Flask, Non-Mag, Mags	82.8097	**Flask, Non-Mag, Mags**	81.8531
Flask + Mags	80.2628	**Flask + Mags**	79.2678
% Mags:	83.38%	**% Mags:**	83.32%

RUN AVG:	**83.35%**

ID:	**PRIM. CLEAN COAL #1 MEDIA**	**ID:**	**PRIM. CLEAN COAL #1 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,576	**Lab #:**	32,576
Weights	Grams	**Weights**	Grams
Flask	68.4144	**Flask**	67.0930
Flask, Non-Mag, Mags	83.8812	**Flask, Non-Mag, Mags**	82.8293
Flask + Mags	81.2839	**Flask + Mags**	80.1496
% Mags:	83.21%	**% Mags:**	82.97%

RUN AVG:	**83.09%**

TOT AVG:	**83.22%**

PLANT B - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 3 of 7

Plant:	**PLANT B**		
ID:	**PRIM. CLEAN COAL #2 MEDIA**	**ID:**	**PRIM. CLEAN COAL #2 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,577	**Lab #:**	32,577
Weights	Grams	**Weights**	Grams
Flask	67.3700	**Flask**	63.8114
Flask, Non-Mag, Mags	82.8024	**Flask, Non-Mag, Mags**	78.8073
Flask + Mags	80.0937	**Flask + Mags**	76.1772
% Mags:	82.45%	**% Mags:**	82.46%

RUN AVG:	**82.45%**

ID:	**PRIM. CLEAN COAL #2 MEDIA**	**ID:**	**PRIM. CLEAN COAL #2 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,578	**Lab #:**	32,578
Weights	Grams	**Weights**	Grams
Flask	68.0960	**Flask**	68.0063
Flask, Non-Mag, Mags	83.8224	**Flask, Non-Mag, Mags**	83.8224
Flask + Mags	81.0730	**Flask + Mags**	81.0375
% Mags:	82.52%	**% Mags:**	82.39%

RUN AVG:	**82.45%**

TOT AVG:	**82.45%**

PLANT B - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 4 of 7

Plant:	**PLANT B**		
ID:	**PRIM. REFUSE MEDIA**	**ID:**	**PRIM. REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,579	**Lab #:**	32,579
Weights	Grams	**Weights**	Grams
Flask	67.7089	**Flask**	63.7009
Flask, Non-Mag, Mags	82.8239	**Flask, Non-Mag, Mags**	78.8122
Flask + Mags	81.2721	**Flask + Mags**	77.2632
% Mags:	89.73%	**% Mags:**	89.75%

RUN AVG:	**89.74%**

ID:	**PRIM. REFUSE MEDIA**	**ID:**	**PRIM. REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,580	**Lab #:**	32,580
Weights	Grams	**Weights**	Grams
Flask	65.2324	**Flask**	68.7357
Flask, Non-Mag, Mags	80.8658	**Flask, Non-Mag, Mags**	83.8916
Flask + Mags	79.2546	**Flask + Mags**	82.3055
% Mags:	89.69%	**% Mags:**	89.53%

RUN AVG:	**89.61%**

TOT AVG:	**89.68%**

PLANT B - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 5 of 7

Plant:	**PLANT B**		
ID:	**SEC. FEED MEDIA**	**ID:**	**SEC. FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,581	**Lab #:**	32,581
Weights	Grams	**Weights**	Grams
Flask	64.7015	**Flask**	68.6489
Flask, Non-Mag, Mags	79.8134	**Flask, Non-Mag, Mags**	83.8197
Flask + Mags	76.8810	**Flask + Mags**	80.8218
% Mags:	80.60%	**% Mags:**	80.24%

RUN AVG:	**80.42%**

ID:	**SEC. FEED MEDIA**	**ID:**	**SEC. FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,582	**Lab #:**	32,582
Weights	Grams	**Weights**	Grams
Flask	67.6908	**Flask**	66.7684
Flask, Non-Mag, Mags	82.8072	**Flask, Non-Mag, Mags**	81.8112
Flask + Mags	79.8778	**Flask + Mags**	78.8878
% Mags:	80.62%	**% Mags:**	80.57%

RUN AVG:	**80.59%**
TOT AVG:	**80.51%**

PLANT B - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 6 of 7

Plant:	**PLANT B**		
ID:	**SEC. CLEAN COAL MEDIA**	**ID:**	**SEC. CLEAN COAL MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,583	**Lab #:**	32,583
Weights	Grams	**Weights**	Grams
Flask	78.4496	**Flask**	65.6639
Flask, Non-Mag, Mags	93.8425	**Flask, Non-Mag, Mags**	80.8062
Flask + Mags	89.3403	**Flask + Mags**	76.3321
% Mags:	70.75%	**% Mags:**	70.45%

RUN AVG:	**70.60%**

ID:	**SEC. CLEAN COAL MEDIA**	**ID:**	**SEC. CLEAN COAL MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,584	**Lab #:**	32,584
Weights	Grams	**Weights**	Grams
Flask	63.7204	**Flask**	77.6111
Flask, Non-Mag, Mags	78.8205	**Flask, Non-Mag, Mags**	92.8314
Flask + Mags	74.3527	**Flask + Mags**	88.3377
% Mags:	70.41%	**% Mags:**	70.48%

RUN AVG:	**70.44%**

TOT AVG:	**70.52%**

PLANT B - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 7 of 7

Plant:	**PLANT B**		
ID:	**SEC. REFUSE (MIDDS) MEDIA**	**ID:**	**SEC. REFUSE (MIDDS) MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	32,585	**Lab #:**	32,585
Weights	Grams	**Weights**	Grams
Flask	68.0539	**Flask**	69.5288
Flask, Non-Mag, Mags	83.8199	**Flask, Non-Mag, Mags**	84.8191
Flask + Mags	82.1810	**Flask + Mags**	83.2382
% Mags:	89.60%	**% Mags:**	89.66%

RUN AVG:	**89.63%**

ID:	**SEC. REFUSE (MIDDS) MEDIA**	**ID:**	**SEC. REFUSE (MIDDS) MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	32,586	**Lab #:**	32,586
Weights	Grams	**Weights**	Grams
Flask	65.9100	**Flask**	81.6971
Flask, Non-Mag, Mags	80.8343	**Flask, Non-Mag, Mags**	96.8033
Flask + Mags	79.3088	**Flask + Mags**	95.1262
% Mags:	89.78%	**% Mags:**	88.90%

RUN AVG:	**89.34%**
TOT AVG:	**89.49%**

PLANT B - HMC PERFORMANCE TEST

SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
PRIM. FEED	#1	1 OF 2	19,956.1	929.5	18,561.2	19,026.6	17,631.7	7.33%
PRIM. FEED	#1	2 OF 2	19,944.7	1,020.7	18,309.4	18,924.0	17,288.7	8.64%
SUBTOTAL FEED	#1	2	39,900.8	1,950.2	36,870.6	37,950.6	34,920.4	7.98%
PRIM. FEED	#2	1 OF 2	19,849.0	823.4	18,216.5	19,025.6	17,393.1	8.58%
PRIM. FEED	#2	2 OF 2	20,265.0	815.3	18,407.6	19,449.7	17,592.3	9.55%
SUBTOTAL FEED	#2	2	40,114.0	1,638.7	36,624.1	38,475.3	34,985.4	9.07%
TOTAL FEED	#2	4	80,014.8	3,588.9	73,494.7	76,425.9	69,905.8	8.53%
PRIM. CLEAN COAL	#1	1 OF 2	13,563.3	1,024.0	12,734.1	12,539.3	11,710.1	6.61%
PRIM. CLEAN COAL	#1	2 OF 2	10,164.7	1,006.6	9,545.4	9,158.1	8,538.8	6.76%
SUBTOTAL CC	#1	2	23,728.0	2,030.6	22,279.5	21,697.4	20,248.9	6.68%
PRIM. CLEAN COAL	#2	1 OF 2	16,997.9	1,013.5	15,779.6	15,984.4	14,766.1	7.62%
PRIM. CLEAN COAL	#2	2 OF 2	13,385.1	964.2	12,339.6	12,420.9	11,375.4	8.42%
SUBTOTAL CC	#2	2	30,383.0	1,977.7	28,119.2	28,405.3	26,141.5	7.97%
TOTAL PRIM. CC	#2	4	54,111.0	4,008.3	50,398.7	50,102.7	46,390.4	7.41%
PRIM. REFUSE	#1	1 OF 4	20,974.2	1,048.1	20,464.2	19,926.1	19,416.1	2.56%
PRIM. REFUSE	#1	2 OF 4	24,292.1	940.6	23,780.6	23,351.5	22,840.0	2.19%
PRIM. REFUSE	#1	3 OF 4	24,445.6	970.4	23,942.4	23,475.2	22,972.0	2.14%
PRIM. REFUSE	#1	4 OF 4	24,428.8	930.0	23,910.0	23,498.8	22,980.0	2.21%
TOTAL PRIM. REF	#1	4	94,140.7	3,889.1	92,097.2	90,251.6	88,208.1	2.26%
SEC. CLEAN COAL	#1	1 OF 4	12,553.8	811.8	11,943.4	11,742.0	11,131.6	5.20%
SEC. CLEAN COAL	#1	2 OF 4	12,998.0	807.9	12,418.4	12,190.1	11,610.5	4.75%
SEC. CLEAN COAL	#1	3 OF 4	12,227.0	802.8	11,689.6	11,424.2	10,886.8	4.70%
SEC. CLEAN COAL	#1	4 OF 4	10,928.7	805.4	10,471.9	10,123.3	9,666.5	4.51%
TOTAL SEC. CC	#1	4	48,707.5	3,227.9	46,523.3	45,479.6	43,295.4	4.80%
SEC. MIDDS	#1	1 OF 4	13,824.2	801.2	13,099.3	13,023.0	12,298.1	5.57%
SEC. MIDDS	#1	2 OF 4	14,630.1	807.9	13,975.7	13,822.2	13,167.8	4.73%
SEC. MIDDS	#1	3 OF 4	12,992.1	800.2	12,436.5	12,191.9	11,636.3	4.56%
SEC. MIDDS	#1	4 OF 4	9,414.7	805.7	9,036.0	8,609.0	8,230.3	4.40%
TOTAL SEC. MIDDS	#1	4	50,861.1	3,215.0	48,547.5	47,646.1	45,332.5	4.86%

PLANT B - HMC PERFORMANCE TEST
MEDIA SAMPLES

PRIMARY FEED MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	8,484.1	TARE WT.	999.7
SOLIDS WT.	3,792.9	% SOLIDS	50.68%
LAB NO.	SIZE	WT (Grams)	WT %
29,989	+ 25M	49.1	1.29%
29,990	25M x 0	3,743.8	98.71%
	Totals	3,792.9	100.00%

PRIM. CLEAN COAL #1 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,912.3	TARE WT.	799.2
SOLIDS WT.	1,816.3	% SOLIDS	44.16%
LAB NO.	SIZE	WT (Grams)	WT %
29,991	+ 25M	19.0	1.05%
29,992	25M x 0	1,797.3	98.95%
	Totals	1,816.3	100.00%

PRIM. CLEAN COAL #2 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	3,828.7	TARE WT.	803.6
SOLIDS WT.	1,367.4	% SOLIDS	45.20%
LAB NO.	SIZE	WT (Grams)	WT %
29,993	+ 25M	10.6	0.78%
29,994	25M x 0	1,356.8	99.22%
	Totals	1,367.4	100.00%

PRIM. REFUSE MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	6,075.9	TARE WT.	816.1
SOLIDS WT.	3,033.0	% SOLIDS	57.66%
LAB NO.	SIZE	WT (Grams)	WT %
29,995	+ 25M	16.8	0.55%
29,996	25M x 0	3,016.2	99.45%
	Totals	3,033.0	100.00%

SEC. FEED MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	6,016.7	TARE WT.	1,000.7
SOLIDS WT.	1,752.1	% SOLIDS	34.93%
LAB NO.	SIZE	WT (Grams)	WT %
29,997	+ 25M	25.0	1.43%
29,998	25M x 0	1,727.1	98.57%
	Totals	1,752.1	100.00%

SEC. CLEAN COAL MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,356.1	TARE WT.	805.4
SOLIDS WT.	933.2	% SOLIDS	26.28%
LAB NO.	SIZE	WT (Grams)	WT %
29,999	+ 25M	20.5	2.20%
30,000	25M x 0	912.7	97.80%
	Totals	933.2	100.00%

SEC. REFUSE (MIDDS) MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	5,842.2	TARE WT.	804.7
SOLIDS WT.	2,319.8	% SOLIDS	46.05%
LAB NO.	SIZE	WT (Grams)	WT %
30,001	+ 25M	9.8	0.42%
30,002	25M x 0	2,310.0	99.58%
	Totals	2,319.8	100.00%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all four (4) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	43,295.4	Grams or	95.450	Lbs
START WEIGHT - REWEIGH:	95.50		Lbs	

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
34,407	2.67

Screen Analysis (Using 7 Containers) 83.5 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
34,408	+ 16mm	20,502.4	Grams	54.13%	2.62
34,409	*16 x 8mm*	16,510.8	Grams	43.59%	2.72
34,410	8 x 4mm	319.2	Grams	0.84%	2.40
34,411	4mm x 0	542.0	Grams	1.43%	2.94
Totals	+16mm x 0	37,874.3	Grams	100.00%	2.67

Total Wt	37,874.3	Grams	100.00%	or	83.5	Lbs
Screen Loss	0.6	Grams		or	0.00	%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	12,360.6	Grams			
LOSS:	54.8	Grams	or	0.44	%

LAB #	GRAVITY	WT	Units	WT%
34,818	1.300	10,515.7	Grams	85.453%
34,819	1.325	1,003.7	Grams	8.156%
34,820	1.350	567.2	Grams	4.609%
34,821	1.375	175.8	Grams	1.429%
34,822	1.400	29.4	Grams	0.239%
34,823	1.425	7.4	Grams	0.060%
34,824	1.450	3.4	Grams	0.028%
34,825	1.500	3.2	Grams	0.026%
	1.550	0.0	Grams	0.000%
	1.600	0.0	Grams	0.000%
	1.700	0.0	Grams	0.000%
	1.800	0.0	Grams	0.000%
	2.000	0.0	Grams	0.000%
	SINK	0.0	Grams	0.000%
TOTAL		12,305.8		100.000%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	242.7	Grams			
LOSS:	0.5	Grams	or	0.21	%

LAB #	GRAVITY	WT	Units	WT%
34,827	1.300	196.6	Grams	81.173%
34,828	1.325	24.0	Grams	9.909%
34,829	1.350	10.3	Grams	4.253%
34,830	1.375	6.6	Grams	2.725%
34,831	1.400	1.4	Grams	0.578%
34,832	1.425	1.2	Grams	0.495%
34,833	1.450	0.2	Grams	0.083%
34,834	1.500	1.3	Grams	0.537%
34,835	1.550	0.2	Grams	0.083%
34,836	1.600	0.1	Grams	0.041%
	1.700	0.0	Grams	0.000%
	1.800	0.0	Grams	0.000%
	2.000	0.0	Grams	0.000%
34,837	SINK	0.3	Grams	0.124%
TOTAL		242.2		100.000%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC MIDDLINGS SAMPLE - SCREEN ANALYSIS

Combine all four (4) middlings samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	45,332.5	Grams or	99.941	Lbs
START WEIGHT - REWEIGH:	99.90	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
35,169	24.06

Screen Analysis (Using 7 Containers) 87.4 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
35,170	+ 16mm	17,281.9	Grams	43.59%	28.30
35,171	*16 x 8mm*	13,199.5	Grams	33.29%	21.31
35,172	8 x 4mm	6,169.6	Grams	15.56%	19.14
35,173	4mm x 0	2,993.7	Grams	7.55%	15.28
Totals	+16mm x 0	39,644.7	Grams	100.00%	23.56

Total Wt	39,644.7	Grams	100.00%	or	87.4	Lbs
Screen Loss	-0.7	Grams		or	0.00	%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC MIDDLINGS SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	9,813.3	Grams			
LOSS:	19.6	Grams	or	0.20	%

LAB #	GRAVITY	WT	Units	WT%
36,191	1.300	1,023.6	Grams	10.452%
36,192	1.325	301.8	Grams	3.082%
36,193	1.350	525.0	Grams	5.361%
36,194	1.375	605.6	Grams	6.184%
36,195	1.400	544.7	Grams	5.562%
36,196	1.425	450.3	Grams	4.598%
36,197	1.450	1,242.6	Grams	12.688%
36,198	1.500	1,986.7	Grams	20.285%
36,199	1.550	929.7	Grams	9.493%
36,200	1.600	677.9	Grams	6.922%
36,201	1.700	1,091.1	Grams	11.141%
36,202	1.800	366.1	Grams	3.738%
36,203	2.000	36.8	Grams	0.376%
36,204	SINK	11.8	Grams	0.120%
TOTAL		9,793.7		100.000%

CIRCUIT B2 - SECONDARY COARSE COAL HMC CIRCUIT

SECONDARY HMC MIDDLINGS SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	8 x 4mm				
START WT:	4,637.1	Grams			
LOSS:	6.9	Grams	or	0.15	%

LAB #	GRAVITY	WT	Units	WT%
36,745	1.300	844.7	Grams	18.243%
36,746	1.325	149.1	Grams	3.220%
36,747	1.350	227.6	Grams	4.916%
36,748	1.375	263.4	Grams	5.689%
36,749	1.400	293.4	Grams	6.337%
36,750	1.425	307.5	Grams	6.641%
36,751	1.450	460.4	Grams	9.943%
36,752	1.500	754.8	Grams	16.302%
36,753	1.550	392.3	Grams	8.473%
36,754	1.600	291.1	Grams	6.287%
36,755	1.700	429.2	Grams	9.270%
36,756	1.800	184.3	Grams	3.980%
36,757	2.000	24.7	Grams	0.533%
36,758	SINK	7.7	Grams	0.166%
TOTAL		4,630.2		100.000%

APPENDIX II-C

Partitioning Data for Plant C

Test Description: CIRCUIT C - COARSE COAL HMC CIRCUIT

Feed Coal Type: 70% White Kn (P), 30% Hernshaw

	Body	Vortex	Apex
Manufacturer:	Krebs	Krebs	Krebs
Diameter (Inch):	26	10	7.6
Wear Condition:	Good	Good	Excellen
Part Alignment:			Fair

Plant Feed Rate (tph):	1500
Circuit Feed Rate(tph):	94
Inlet Pressure (psi):	10
Gauge Position (inch):	30
Head (Diameters):	9.0
Magnetite Grade:	B

Tracer Size (mm):	32
Tracer Shape:	Cubes
Weighting (Y/N)?	N
SG Cutpoint (SG50)	1.512
Probable Error (Ep):	0.015
Low SG Offset:	0.000

Tracer SG	Tracer in Feed	Overflow (Clean Coal) A	B	C	D	E	F	Sum	Underflow (Refuse) A	B	C	D	E	F	Sum	Tracers Collected	Tracers Lost	Refuse Partition	Fitted Partition	Weight Factor	Weighted Error
1.32	20	3	2	2	6	6	1	20	0	0					0	1.00	0.00	0.00	0.00	0.10	0.00
1.36	20	2	1	4	6	6	0	19	0	0					0	0.95	0.05	0.00	0.00	0.10	0.00
1.40	20	2	3	5	1	4	1	16	0	0					0	0.80	0.20	0.00	0.00	0.10	0.00
1.42	25	4	4	3	5	5	3	24	0	0					0	0.96	0.04	0.00	0.00	0.10	0.00
1.44	20	8	2	4	1	3	0	18	0	0					0	0.90	0.10	0.00	0.01	0.10	0.00
1.46	20	1	4	3	2	2	2	14	0	0					0	0.70	0.30	0.00	0.02	0.10	0.00
1.48	20	0	0	0	0	2	4	6	0	0					0	0.30	0.70	0.00	0.09	0.10	0.01
1.50	20	1	0	0	1	2	0	4	2	0					2	0.30	0.70	0.33	0.29	0.33	0.00
1.52	25	0	2	0	0	1	0	3	3	3					6	0.36	0.64	0.67	0.64	0.33	0.00
1.54	20	0	0	0	0	0	2	2	8	2					10	0.60	0.40	0.83	0.89	0.17	0.00
1.56	20	0	0	0	0	0	1	1	6	8					14	0.75	0.25	0.93	0.97	0.10	0.00
1.58	20	0	0	0	0	0	0	0	9	7					16	0.80	0.20	1.00	0.99	0.10	0.00
1.60	25	0	0	0	0	0	0	0	6	13					19	0.76	0.24	1.00	1.00	0.10	0.00
1.62	5	0	0	0	0	0	0	0	2	3					5	1.00	0.00	1.00	1.00	0.10	0.00
1.64	5	0	0	0	0	0	0	0	4	1					5	1.00	0.00	1.00	1.00	0.10	0.00
1.66	5	0	0	0	0	0	0	0	0	5					5	1.00	0.00	1.00	1.00	0.10	0.00
1.68	5	0	0	0	0	0	0	0	3	2					5	1.00	0.00	1.00	1.00	0.10	0.00
1.70	5	0	0	0	0	0	0	0	1	3					4	0.80	0.20	1.00	1.00	0.10	0.00
1.72	5	0	0	0	0	0	0	0	2	2					4	0.80	0.20	1.00	1.00	0.10	0.00
1.74	5	0	0	0	0	0	0	0	2	1					3	0.60	0.40	1.00	1.00	0.10	0.00
1.76	5	0	0	0	0	0	0	0	0	4					4	0.80	0.20	1.00	1.00	0.10	0.00
1.78	5	0	0	0	0	0	0	0	2	3					5	1.00	0.00	1.00	1.00	0.10	0.00
1.80	5	0	0	0	0	0	0	0	3	2					5	1.00	0.00	1.00	1.00	0.10	0.00
Known Dropped		0	0	0	0	2	0	2	10	0					10					Total WSSQ:	0.01

Description: CIRCUIT C - COARSE COAL HMC CIRCUIT

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections Real World	O&M Factors	Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1.2	0.01	0.013
16	8	11.31	0.003	1.5	1.2	0.01	0.016
8	4	5.66	0.007	1.5	1.2	0.01	0.022
4	2	2.83	0.013	1.5	1.2	0.01	0.034
2	1	1.41	0.026	1.5	1.2	0.01	0.057
1	0.5	0.71	0.052	1.5	1.2	0.01	0.104

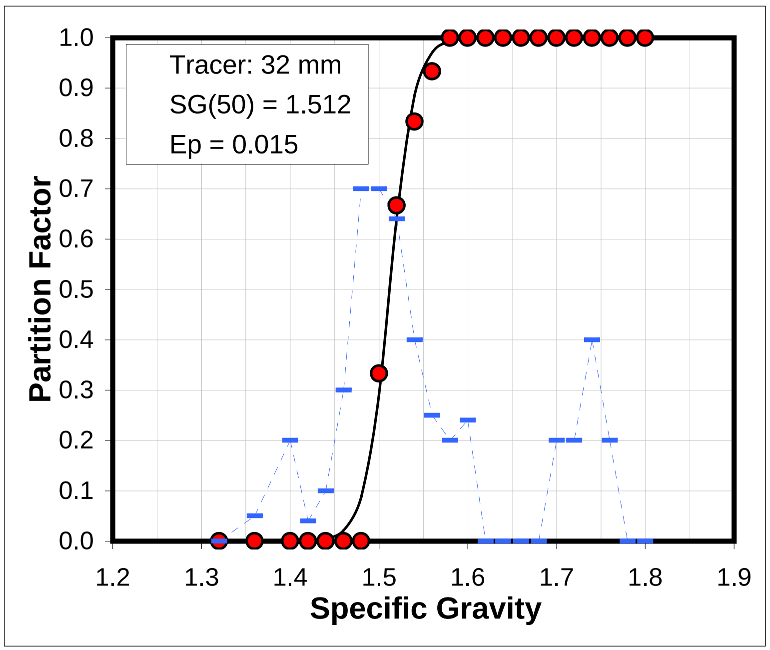
Comments: Tracer retention from 1.47-1.53 SG
O&M correction for low pressure.

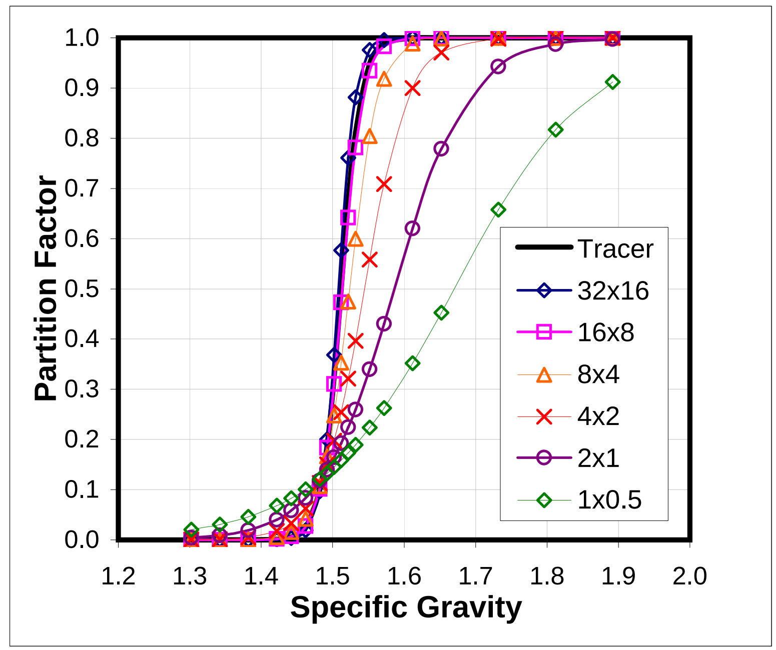
	SG	Split
O/F:	1.310	0.875
U/F:	1.630	0.125
Feed:	1.350	1.000

	SG	Split
Pivot:	1.485	0.125
O/F-U/F	0.32	

Obs.	Marcy Scale SG Feed	O/F	U/F
1	1.35	1.295	1.62
2		1.3	1.64
3		1.31	
4		1.32	
5		1.325	
Avg.	1.350	1.310	1.630

Size	32	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.512	1.508	1.514	1.524	1.545	1.587	1.670
Ep	0.015	0.013	0.016	0.022	0.034	0.057	0.10
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





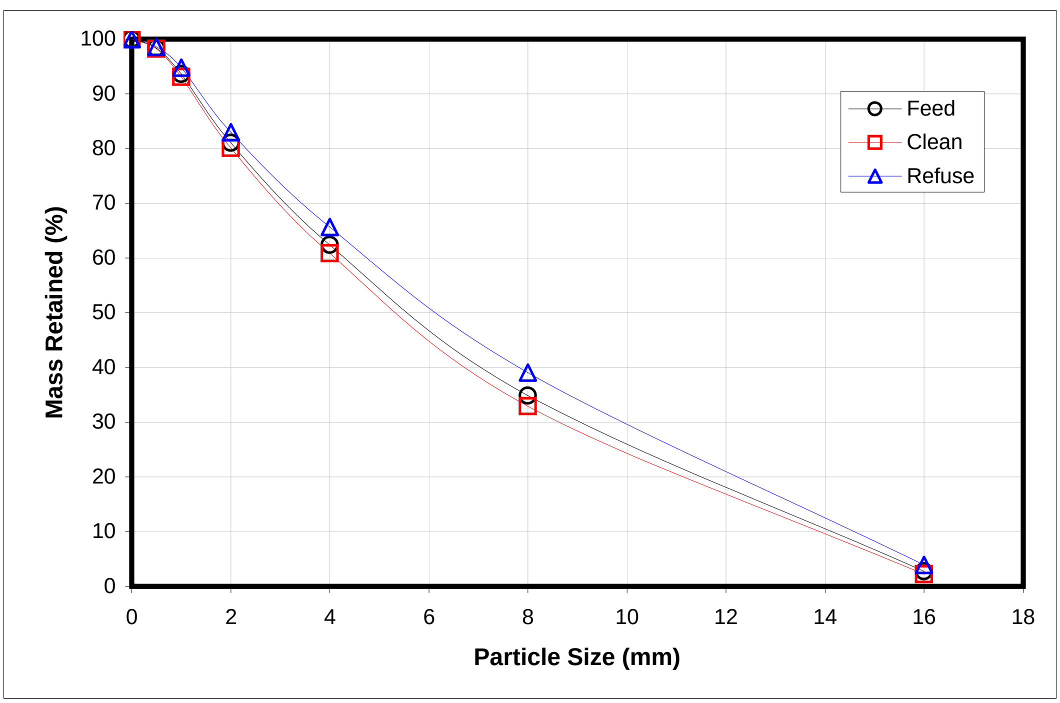
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT C - COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	195.3	Clean Yield (%):	68.74
Refuse Rate (t/hr):	88.8	Refuse Yield (%):	31.26
Feed Rate (t/hr):	284.1		

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	2.22	5.26	3.95	83.22	2.76	40.14
16	8	11.31	30.70	4.75	35.12	84.18	32.08	31.93
8	4	5.66	27.98	4.88	26.62	82.22	27.55	28.24
4	2	2.83	19.25	4.97	17.28	81.16	18.63	27.06
2	1	1.41	12.94	5.34	11.84	79.70	12.59	27.19
1	0.5	0.71	5.16	6.00	3.79	76.11	4.74	23.55
0.5	0.001	0.02	1.75	19.46	1.40	75.00	1.64	34.23
		Totals	100.00	5.24	100.00	82.13	100.00	29.28

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	55.26	44.74	100.00	2.22	3.95	2.76
16	8	11.31	65.78	34.22	100.00	32.92	39.07	34.84
8	4	5.66	69.80	30.20	100.00	60.90	65.69	62.40
4	2	2.83	71.00	29.00	100.00	80.14	82.97	81.03
2	1	1.41	70.62	29.38	100.00	93.08	94.81	93.62
1	0.5	0.71	74.96	25.04	100.00	98.25	98.60	98.36
0.5	0.001	0.02	73.41	26.59	100.00	100.00	100.00	100.00
		Totals	68.74	31.26	100.00			



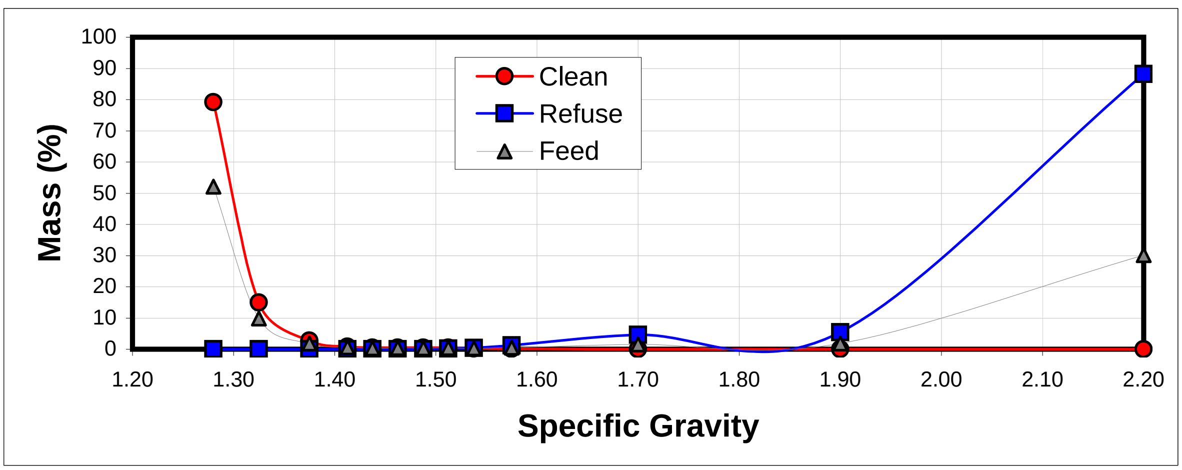
Circuit: CIRCUIT C - COARSE COAL HMC CIRCUIT
Size: 16 x 8 mm

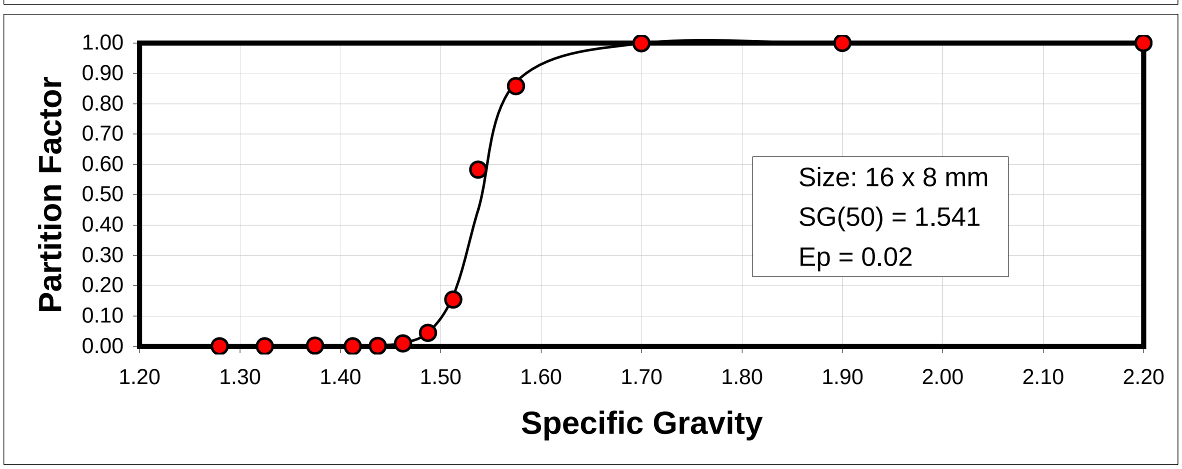
Clean Yield (%) 65.78
Refuse Yield (%) 34.22

SG Cutpoint (SG50) 1.541
Probable Error (Ep): 0.020

Weighting (Y/N)? Y
Low SG Offset: 0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	79.14	0.01	52.06	0.00	0.00	0.10	0.00
1.300	1.350	1.325	14.94	0.00	9.83	0.00	0.00	0.10	0.00
1.350	1.400	1.375	2.79	0.01	1.84	0.00	0.00	0.10	0.00
1.400	1.425	1.413	0.86	0.00	0.56	0.00	0.00	0.10	0.00
1.425	1.450	1.438	0.47	0.00	0.31	0.00	0.00	0.10	0.00
1.450	1.475	1.463	0.56	0.01	0.37	0.01	0.01	0.10	0.00
1.475	1.500	1.488	0.48	0.04	0.33	0.04	0.05	0.10	0.00
1.500	1.525	1.513	0.49	0.17	0.38	0.15	0.17	0.15	0.01
1.525	1.550	1.538	0.17	0.45	0.27	0.58	0.45	0.42	0.10
1.550	1.600	1.575	0.10	1.19	0.47	0.86	0.87	0.14	0.01
1.600	1.800	1.700	0.00	4.57	1.56	1.00	1.00	0.10	0.00
1.800	2.000	1.900	0.00	5.39	1.84	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.00	88.16	30.17	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.12

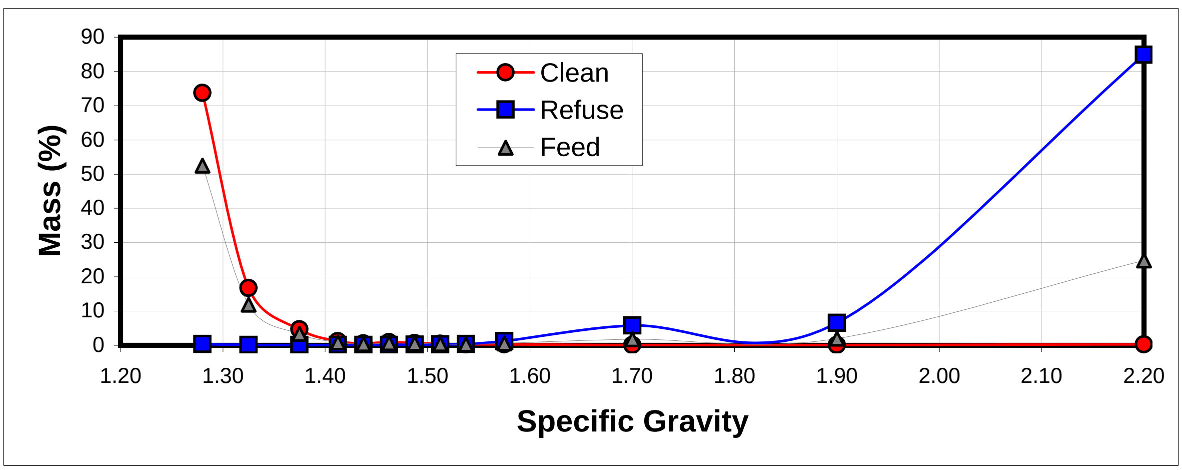


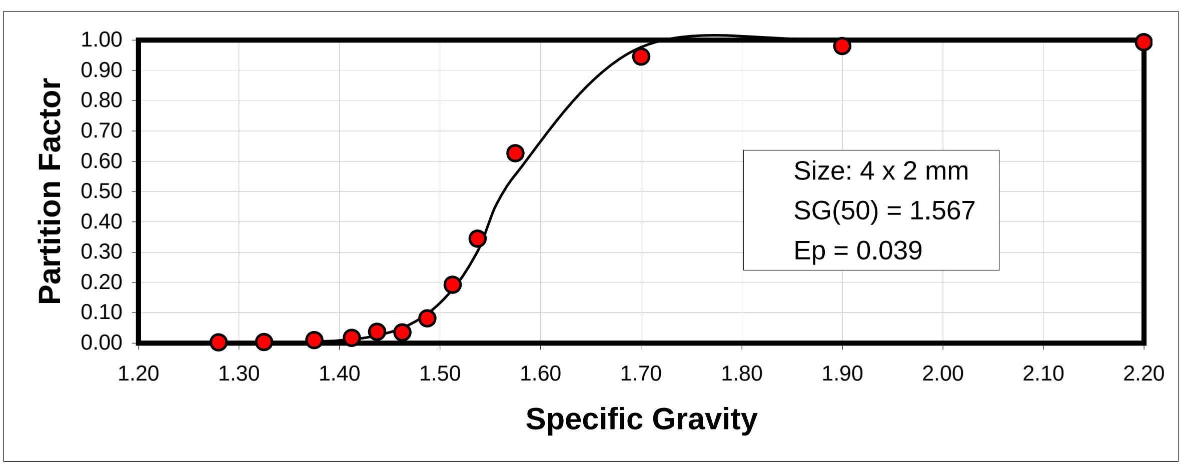


Circuit:	CIRCUIT C - COARSE COAL HMC CIRCUIT
Size:	4 x 2 mm

Clean Yield (%)	71.00	SG Cutpoint (SG50)	1.567	Weighting (Y/N)?	Y
Refuse Yield (%)	29.00	Probable Error (Ep):	0.039	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	73.75	0.34	52.46	0.00	0.00	0.10	0.00
1.300	1.350	1.325	16.70	0.13	11.90	0.00	0.00	0.10	0.00
1.350	1.400	1.375	4.68	0.11	3.35	0.01	0.00	0.10	0.00
1.400	1.425	1.413	1.23	0.05	0.89	0.02	0.01	0.10	0.00
1.425	1.450	1.438	0.57	0.05	0.42	0.04	0.03	0.10	0.01
1.450	1.475	1.463	0.89	0.08	0.66	0.04	0.05	0.10	0.02
1.475	1.500	1.488	0.69	0.15	0.54	0.08	0.10	0.10	0.03
1.500	1.525	1.513	0.47	0.27	0.41	0.19	0.18	0.19	0.01
1.525	1.550	1.538	0.28	0.36	0.30	0.34	0.30	0.34	0.01
1.550	1.600	1.575	0.29	1.17	0.54	0.63	0.56	0.37	0.03
1.600	1.800	1.700	0.14	5.83	1.79	0.94	0.98	0.10	0.10
1.800	2.000	1.900	0.05	6.58	1.95	0.98	1.00	0.10	0.04
2.000	2.400	2.200	0.26	84.87	24.79	0.99	1.00	0.10	0.01
		Totals	100.00	100.00	100.00			WSSQ:	0.27

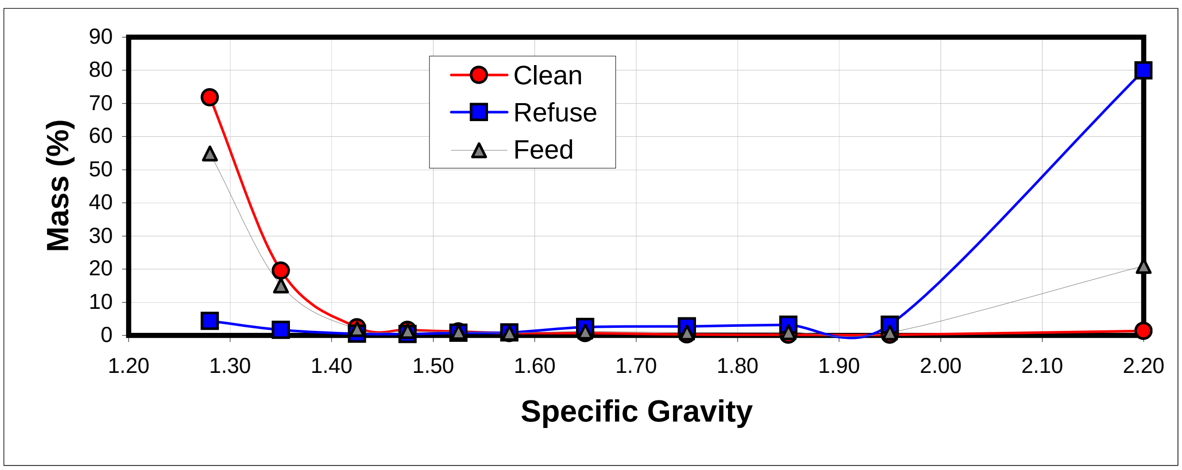


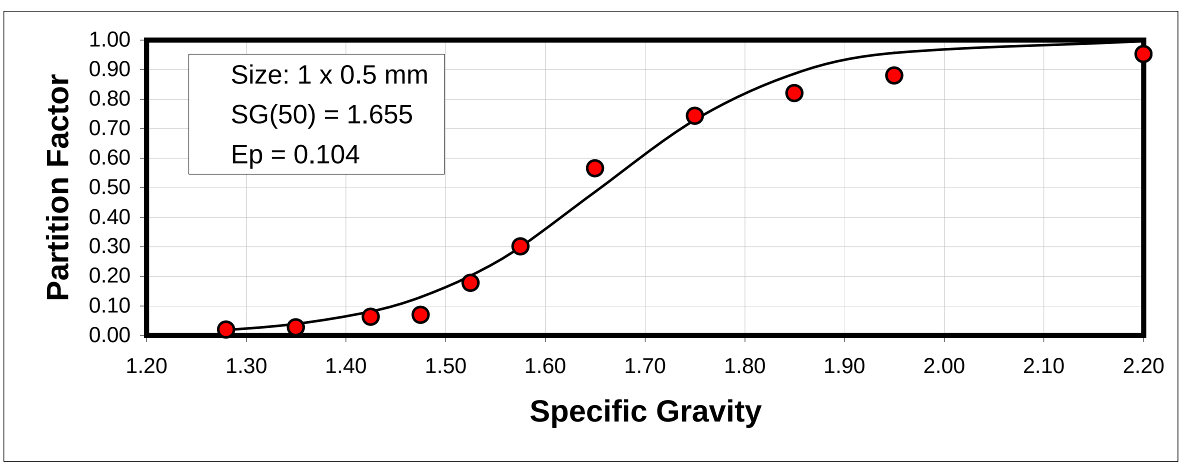


Circuit:	CIRCUIT C - COARSE COAL HMC CIRCUIT
Size:	1 x 0.5 mm

Clean Yield (%)	74.96	SG Cutpoint (SG50)	1.655	Weighting (Y/N)?	N
Refuse Yield (%)	25.04	Probable Error (Ep):	0.104	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	71.86	4.32	54.95	0.02	0.02	0.10	0.00
1.300	1.400	1.350	19.53	1.66	15.05	0.03	0.04	0.10	0.00
1.400	1.450	1.425	2.45	0.49	1.96	0.06	0.08	0.10	0.00
1.450	1.500	1.475	1.67	0.38	1.35	0.07	0.13	0.10	0.00
1.500	1.550	1.525	1.14	0.74	1.04	0.18	0.20	0.18	0.00
1.550	1.600	1.575	0.68	0.88	0.73	0.30	0.30	0.30	0.00
1.600	1.700	1.650	0.65	2.54	1.12	0.57	0.49	0.43	0.01
1.700	1.800	1.750	0.31	2.68	0.90	0.74	0.73	0.26	0.00
1.800	1.900	1.850	0.23	3.19	0.97	0.82	0.89	0.18	0.00
1.900	2.000	1.950	0.15	3.18	0.90	0.88	0.96	0.12	0.01
2.000	2.400	2.200	1.33	79.95	21.01	0.95	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.02

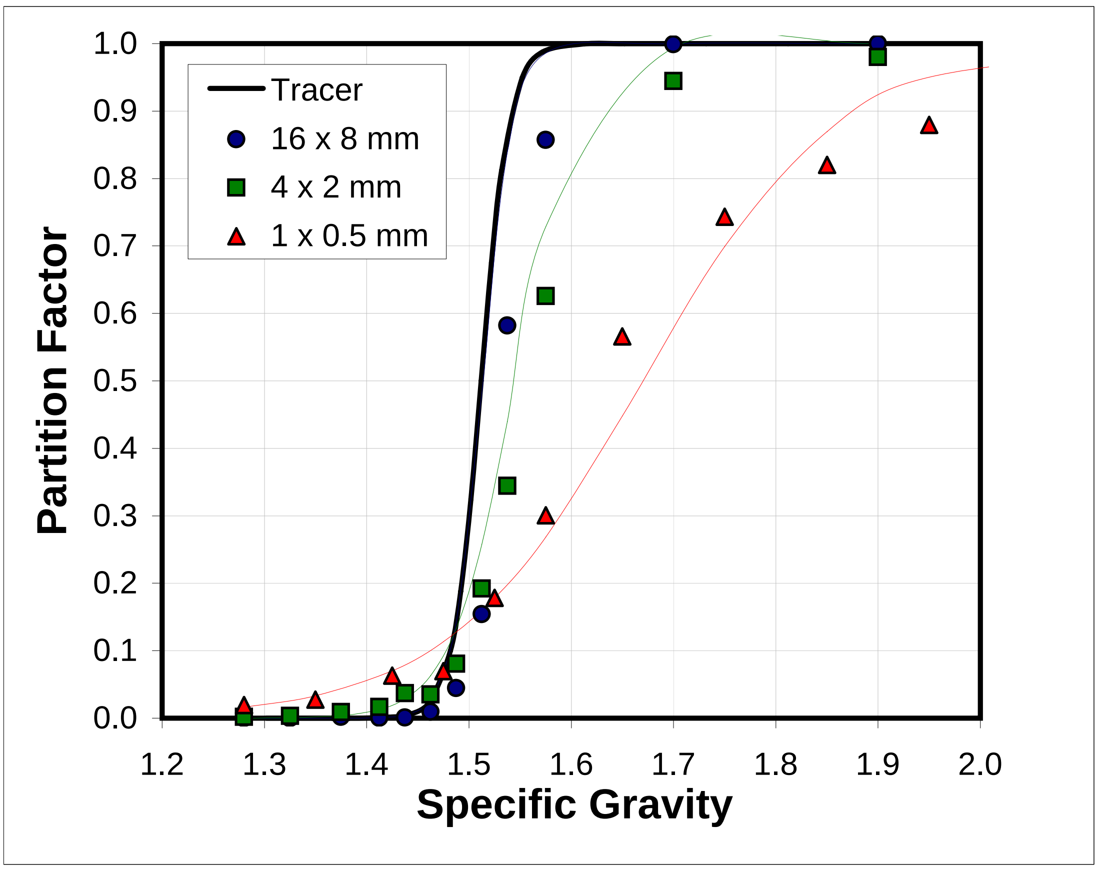


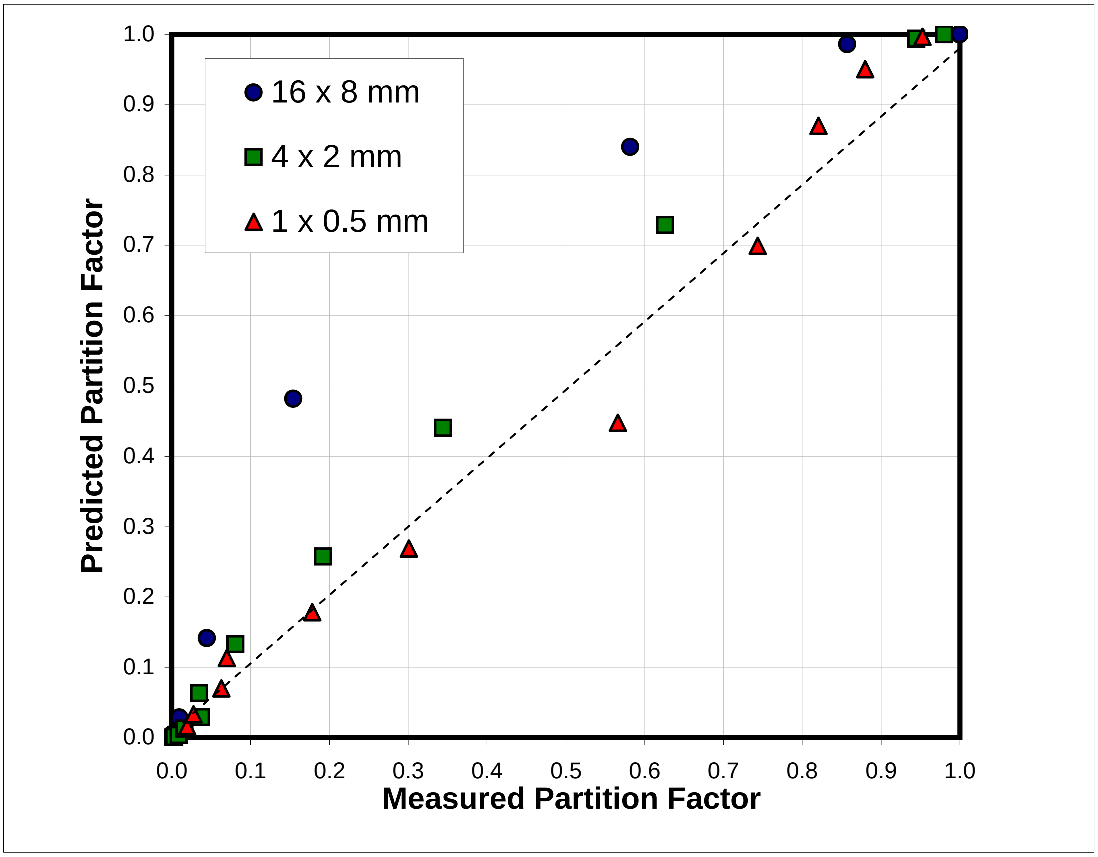


Circuit: CIRCUIT C - COARSE COAL HMC CIRCUIT

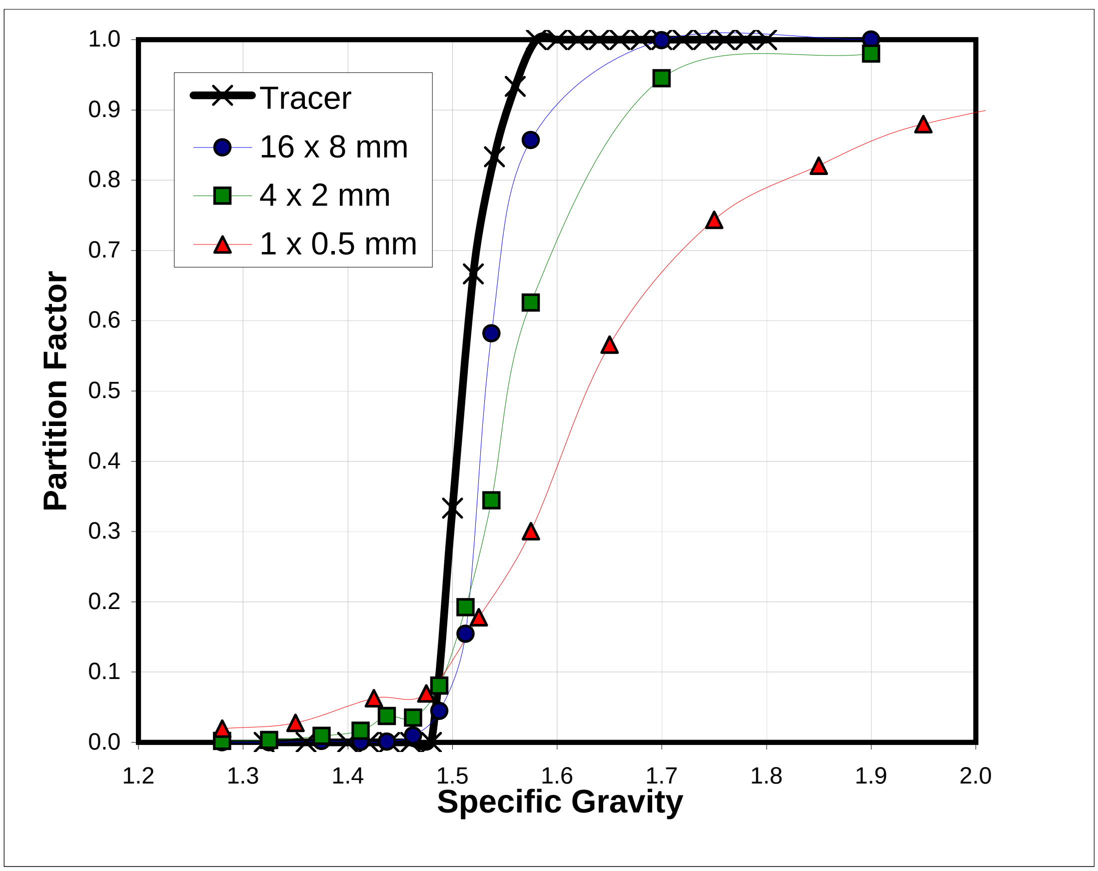
	Measured 16 x 8 mm	Predicted 16 x 8 mm		Measured 4 x 2 mm	Predicted 4 x 2 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.541	1.514	SG(50):	1.567	1.545	SG(50):	1.655	1.670
Ep:	0.020	0.016	Ep:	0.039	0.034	Ep:	0.104	0.104
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16 x 8 mm	Predicted 16 x 8 mm	SG	Measured 4 x 2 mm	Predicted 4 x 2 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.28	0.00	0.000	1.28	0.00	0.000	1.28	0.02	0.016
1.33	0.00	0.000	1.33	0.00	0.001	1.35	0.03	0.033
1.38	0.00	0.000	1.38	0.01	0.004	1.43	0.06	0.070
1.41	0.00	0.001	1.41	0.02	0.013	1.48	0.07	0.113
1.44	0.00	0.005	1.44	0.04	0.029	1.53	0.18	0.178
1.46	0.01	0.028	1.46	0.04	0.063	1.58	0.30	0.269
1.49	0.04	0.142	1.49	0.08	0.133	1.65	0.57	0.448
1.51	0.15	0.482	1.51	0.19	0.258	1.75	0.74	0.699
1.54	0.58	0.840	1.54	0.34	0.440	1.85	0.82	0.870
1.58	0.86	0.986	1.58	0.63	0.729	1.95	0.88	0.950
1.70	1.00	1.000	1.70	0.94	0.994	2.20	0.95	0.996
1.90	1.00	1.000	1.90	0.98	1.000			





16 x 8 mm
4 x 2 mm
1 x 0.5 mm
Predicted Partition Factor
Measured Partition Factor
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0



Tracer
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
Partition Factor
Specific Gravity
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0

PLANT C - HMC PERFORMANCE TEST
SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
208-A CLEAN COAL	#1	1 OF 1	17,019.8	1,045.8	15,040.3	15,974.0	13,994.5	12.39%
208-B CLEAN COAL	#2	1 OF 1	21,071.0	1,052.6	17,850.7	20,018.4	16,798.1	16.09%
208-C CLEAN COAL	#3	1 OF 1	19,587.9	902.9	17,025.8	18,685.0	16,122.9	13.71%
TOTAL CLEAN COAL		3	57,678.7	3,001.3	49,916.8	54,677.4	46,915.5	14.20%
HMC REFUSE		1 OF 3	20,305.2	1,053.9	19,004.7	19,251.3	17,950.8	6.76%
HMC REFUSE		2 OF 3	21,800.9	912.1	20,404.7	20,888.8	19,492.6	6.68%
HMC REFUSE		3 OF 3	19,315.0	1,029.6	18,056.1	18,285.4	17,026.5	6.88%
TOTAL REFUSE		3	61,421.1	2,995.6	57,465.5	58,425.5	54,469.9	6.77%

PLANT C - HMC PERFORMANCE TEST
MEDIA SAMPLES

FEED MEDIA - TEST BANK

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	3,395.5	TARE WT.	1,036.3
SOLIDS WT.	1,296.1	% SOLIDS	54.94%
LAB NO.	SIZE	WT (Grams)	WT %
942,493	+ 25M	435.9	33.63%
942,494	25M x 0	860.2	66.37%
	Totals	1,296.1	100.00%

FEED MEDIA - NON TEST BANK

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	3,291.3	TARE WT.	1,040.4
SOLIDS WT.	1,203.9	% SOLIDS	53.49%
LAB NO.	SIZE	WT (Grams)	WT %
942,495	+ 25M	364.8	30.30%
942,496	25M x 0	839.1	69.70%
	Totals	1,203.9	100.00%

CLEAN COAL 208 A/B/C MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	4,740.7	TARE WT.	1,038.7
SOLIDS WT.	1,303.6	% SOLIDS	35.21%
LAB NO.	SIZE	WT (Grams)	WT %
942,497	+ 25M	11.9	0.91%
942,498	25M x 0	1,291.7	99.09%
	Totals	1,303.6	100.00%

CLEAN COAL 208 D/E/F MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	10,409.7	TARE WT.	1,043.6
SOLIDS WT.	3,647.4	% SOLIDS	38.94%
LAB NO.	SIZE	WT (Grams)	WT %
942,499	+ 25M	198.8	5.45%
942,500	25M x 0	3,448.6	94.55%
	Totals	3,647.4	100.00%

REFUSE MEDIA 212-A

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	3,020.1	TARE WT.	996.9
SOLIDS WT.	1,051.7	% SOLIDS	51.98%
LAB NO.	SIZE	WT (Grams)	WT %
942,501	+ 25M	28.3	2.69%
942,502	25M x 0	1,023.4	97.31%
	Totals	1,051.7	100.00%

REFUSE MEDIA 212-B

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	2,893.0	TARE WT.	978.3
SOLIDS WT.	1,021.2	% SOLIDS	53.33%
LAB NO.	SIZE	WT (Grams)	WT %
942,503	+ 25M	66.9	6.55%
942,504	25M x 0	954.3	93.45%
	Totals	1,021.2	100.00%

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 6

Plant: PLANT C

ID:	**FEED MEDIA - TEST BANK**	**ID:**	**FEED MEDIA - TEST BANK**
Run:	1-A	**Run:**	1-B
Lab #:	943,763	**Lab #:**	943,763
Weights	Grams	**Weights**	Grams
Flask	64.6473	**Flask**	66.3579
Flask, Non-Mag, Mags	104.5931	**Flask, Non-Mag, Mags**	106.6045
Flask + Mags	97.2117	**Flask + Mags**	99.2185
% Mags:	81.52%	**% Mags:**	81.65%

RUN AVG:	**81.58%**

ID:	**FEED MEDIA - TEST BANK**	**ID:**	**FEED MEDIA - TEST BANK**
Run:	2-A	**Run:**	2-B
Lab #:	943,764	**Lab #:**	943,764
Weights	Grams	**Weights**	Grams
Flask	67.0969	**Flask**	68.4779
Flask, Non-Mag, Mags	107.4585	**Flask, Non-Mag, Mags**	108.9105
Flask + Mags	98.8552	**Flask + Mags**	100.5912
% Mags:	78.68%	**% Mags:**	79.42%

RUN AVG:	**79.05%**

TOT AVG:	**80.32%**

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 2 of 6

ID:	**FEED MEDIA - NON TEST BANK**	**ID:**	**FEED MEDIA - NON TEST BANK**
Run:	1-A	**Run:**	1-B
Lab #:	943,765	**Lab #:**	943,765
Weights	Grams	**Weights**	Grams
Flask	68.1023	**Flask**	68.0124
Flask, Non-Mag, Mags	108.7057	**Flask, Non-Mag, Mags**	108.1218
Flask + Mags	100.3385	**Flask + Mags**	99.9019
% Mags:	79.39%	**% Mags:**	79.51%

RUN AVG:	**79.45%**

ID:	**FEED MEDIA - NON TEST BANK**	**ID:**	**FEED MEDIA - NON TEST BANK**
Run:	2-A	**Run:**	2-B
Lab #:	943,766	**Lab #:**	943,766
Weights	Grams	**Weights**	Grams
Flask	78.4565	**Flask**	66.5311
Flask, Non-Mag, Mags	118.5970	**Flask, Non-Mag, Mags**	106.3491
Flask + Mags	110.4756	**Flask + Mags**	98.4879
% Mags:	79.77%	**% Mags:**	80.26%

RUN AVG:	**80.01%**

TOT AVG:	**79.73%**

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 3 of 6

ID:	**CLEAN COAL 208 A/B/C MEDIA**	**ID:**	**CLEAN COAL 208 A/B/C MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	943,767	**Lab #:**	943,767
Weights	Grams	**Weights**	Grams
Flask	64.6493	**Flask**	66.3596
Flask, Non-Mag, Mags	104.4517	**Flask, Non-Mag, Mags**	106.3909
Flask + Mags	93.7513	**Flask + Mags**	95.5942
% Mags:	73.12%	**% Mags:**	73.03%

RUN AVG:	**73.07%**

ID:	**CLEAN COAL 208 A/B/C MEDIA**	**ID:**	**CLEAN COAL 208 A/B/C MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	943,768	**Lab #:**	943,768
Weights	Grams	**Weights**	Grams
Flask	67.0989	**Flask**	68.4784
Flask, Non-Mag, Mags	107.3654	**Flask, Non-Mag, Mags**	108.7806
Flask + Mags	97.2601	**Flask + Mags**	98.5673
% Mags:	74.90%	**% Mags:**	74.66%

RUN AVG:	**74.78%**

TOT AVG:	**73.93%**

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 4 of 6

ID:	**CLEAN COAL 208 D/E/F MEDIA**	**ID:**	**CLEAN COAL 208 D/E/F MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	943,769	**Lab #:**	943,769
Weights	Grams	**Weights**	Grams
Flask	64.6505	**Flask**	67.4880
Flask, Non-Mag, Mags	104.8242	**Flask, Non-Mag, Mags**	107.6114
Flask + Mags	90.1386	**Flask + Mags**	93.2785
% Mags:	63.44%	**% Mags:**	64.28%

RUN AVG:	**63.86%**

ID:	**CLEAN COAL 208 D/E/F MEDIA**	**ID:**	**CLEAN COAL 208 D/E/F MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	943,770	**Lab #:**	943,770
Weights	Grams	**Weights**	Grams
Flask	66.3602	**Flask**	68.4204
Flask, Non-Mag, Mags	106.6037	**Flask, Non-Mag, Mags**	108.5989
Flask + Mags	92.1273	**Flask + Mags**	93.8902
% Mags:	64.03%	**% Mags:**	63.39%

RUN AVG:	**63.71%**

TOT AVG:	**63.79%**

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 5 of 6

ID:	**REFUSE MEDIA 212-A**	**ID:**	**REFUSE MEDIA 212-A**
Run:	1-A	**Run:**	1-B
Lab #:	943,771	**Lab #:**	943,771
Weights	Grams	**Weights**	Grams
Flask	67.0993	**Flask**	67.3759
Flask, Non-Mag, Mags	107.5292	**Flask, Non-Mag, Mags**	107.6309
Flask + Mags	100.9706	**Flask + Mags**	100.7521
% Mags:	83.78%	**% Mags:**	82.91%

RUN AVG:	**83.34%**

ID:	**REFUSE MEDIA 212-A**	**ID:**	**REFUSE MEDIA 212-A**
Run:	2-A	**Run:**	2-B
Lab #:	943,772	**Lab #:**	943,772
Weights	Grams	**Weights**	Grams
Flask	63.8184	**Flask**	68.1021
Flask, Non-Mag, Mags	103.5134	**Flask, Non-Mag, Mags**	108.8047
Flask + Mags	97.5739	**Flask + Mags**	102.5479
% Mags:	85.04%	**% Mags:**	84.63%

RUN AVG:	**84.83%**

TOT AVG:	**84.09%**

PLANT C - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 6 of 6

ID:	**REFUSE MEDIA 212-B**	**ID:**	**REFUSE MEDIA 212-B**
Run:	1-A	**Run:**	1-B
Lab #:	943,773	**Lab #:**	943,773
Weights	Grams	**Weights**	Grams
Flask	68.0128	**Flask**	78.4569
Flask, Non-Mag, Mags	108.7876	**Flask, Non-Mag, Mags**	118.7268
Flask + Mags	101.3241	**Flask + Mags**	111.9558
% Mags:	81.70%	**% Mags:**	83.19%

RUN AVG:	**82.44%**

ID:	**REFUSE MEDIA 212-B**	**ID:**	**REFUSE MEDIA 212-B**
Run:	2-A	**Run:**	2-B
Lab #:	943,774	**Lab #:**	943,774
Weights	Grams	**Weights**	Grams
Flask	63.7065	**Flask**	65.2387
Flask, Non-Mag, Mags	103.7744	**Flask, Non-Mag, Mags**	105.7403
Flask + Mags	96.7215	**Flask + Mags**	98.2441
% Mags:	82.40%	**% Mags:**	81.49%

RUN AVG:	**81.94%**

TOT AVG:	**82.19%**

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all three (3) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT: 46,915.5 Grams or 103.431 Lbs

START WEIGHT - REWEIGH: 103.5 Lbs

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
942,505	5.13

Screen Analysis (Using 7 Containers) 90.4 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
942,506	+ 16mm	907.7	Grams	2.22%	5.26
942,507	*16 x 8mm*	12,567.2	Grams	30.70%	4.75
942,508	8 x 4mm	11,451.8	Grams	27.98%	4.88
Totals	+4mm	24,926.7	Grams	60.90%	4.83

Total +4mm Wt	24,926.7	Grams	60.90%			
Total -4mm Wt	16,005.7	Grams	39.10%			
Total Wt	40,932.4	Grams	100.00%	or	90.2	Lbs
Screen Loss	72.4	Grams		or	0.18	%
-4mm Split Wt	16,005.7	Grams	(Use All)			
Screen Loss	68.4	Grams		or	0.43	%
Total Scr Loss	140.8	Grams		or	0.34	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
942,509	*4 x 2mm*	7,844.2	Grams	19.25%	4.97
942,510	2 x 1mm	5,273.1	Grams	12.94%	5.34
942,511	*1 x 0.5mm*	2,104.9	Grams	5.16%	6.00
942,512	0.5mm x 0	715.1	Grams	1.75%	19.46
Totals	4mm x 0	15,937.3	Grams	39.10%	5.88
Totals	+16mm x 0	40,864.0	Grams	100.00%	5.24

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	9,433.1	Grams			
LOSS:	2.1	Grams	or	0.02	%

LAB #	GRAVITY	WT	Units	WT%
942,513	1.300	7,463.5	Grams	79.14%
942,514	1.350	1,409.3	Grams	14.94%
942,515	1.400	263.2	Grams	2.79%
942,516	1.425	80.9	Grams	0.86%
942,517	1.450	44.3	Grams	0.47%
942,518	1.475	52.4	Grams	0.56%
942,519	1.500	45.0	Grams	0.48%
942,520	1.525	46.6	Grams	0.49%
942,521	1.550	15.9	Grams	0.17%
942,522	1.600	9.7	Grams	0.10%
942,523	1.800	0.2	Grams	0.00%
	2.000	0.0	Grams	0.00%
	SINK	0.0	Grams	0.00%
TOTAL		9,431.0	Grams	100.00%

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	5,905.0	Grams			
LOSS:	23.8	Grams	or	0.40	%

LAB #	GRAVITY	WT	Units	WT%
943,110	1.300	4,337.3	Grams	73.75%
943,111	1.350	982.4	Grams	16.70%
943,112	1.400	275.1	Grams	4.68%
943,113	1.425	72.3	Grams	1.23%
943,114	1.450	33.3	Grams	0.57%
943,115	1.475	52.6	Grams	0.89%
943,116	1.500	40.8	Grams	0.69%
943,117	1.525	27.7	Grams	0.47%
943,118	1.550	16.4	Grams	0.28%
943,119	1.600	16.8	Grams	0.29%
943,120	1.800	8.2	Grams	0.14%
943,121	2.000	3.2	Grams	0.05%
943,122	SINK	15.1	Grams	0.26%
TOTAL		5,881.2	Grams	100.00%

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	1,595.9	Grams			
LOSS:	10.9	Grams	or	0.68	%

LAB #	GRAVITY	WT	Units	WT%
944,198	1.300	1,139.0	Grams	71.86%
944,199	1.400	309.5	Grams	19.53%
944,200	1.450	38.9	Grams	2.45%
944,201	1.500	26.5	Grams	1.67%
944,202	1.550	18.0	Grams	1.14%
944,203	1.600	10.8	Grams	0.68%
944,204	1.700	10.3	Grams	0.65%
944,205	1.800	4.9	Grams	0.31%
944,206	1.900	3.7	Grams	0.23%
944,207	2.000	2.3	Grams	0.15%
944,208	SINK	21.1	Grams	1.33%
TOTAL		1,585.0	Grams	100.00%

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all three (3) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	54,469.9	Grams or	120.086	Lbs
START WEIGHT - REWEIGH:	120.2	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
943,102	82.09

Screen Analysis (Using 7 Containers) 104.9 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
943,103	+ 16mm	1,874.2	Grams	3.95%	83.22
943,104	*16 x 8mm*	16,677.6	Grams	35.12%	84.18
943,105	8 x 4mm	12,639.4	Grams	26.62%	82.22
Totals	+4mm	31,191.2	Grams	65.69%	83.33

Total +4mm Wt	31,191.2	Grams	65.69%			
Total -4mm Wt	16,290.1	Grams	34.31%			
Total Wt	47,481.3	Grams	100.00%			
Screen Loss	100.5	Grams		or	0.21	%
-4mm Split Wt	16,290.1	Grams	(Use All)			
Screen Loss	20.3	Grams		or	0.12	%
Total Scr Loss	120.8	Grams		or	0.25	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
943,106	*4 x 2mm*	8,195.9	Grams	17.28%	81.16
943,107	2 x 1mm	5,612.7	Grams	11.84%	79.70
943,108	*1 x 0.5mm*	1,798.6	Grams	3.79%	76.11
943,109	0.5mm x 0	662.6	Grams	1.40%	75.00
Totals	4mm x 0	16,269.8	Grams	34.31%	79.85
Totals	+16mm x 0	47,461.0	Grams	100.00%	82.13

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	12,601.1	Grams			
LOSS:	9.5	Grams	or	0.08	%

LAB #	GRAVITY	WT	Units	WT%
946,119	1.300	1.0	Grams	0.01%
946,120	1.350	0.1	Grams	0.00%
946,121	1.400	1.3	Grams	0.01%
946,122	1.425	0.1	Grams	0.00%
946,123	1.450	0.1	Grams	0.00%
946,124	1.475	1.3	Grams	0.01%
946,125	1.500	5.4	Grams	0.04%
946,126	1.525	21.8	Grams	0.17%
946,127	1.550	56.8	Grams	0.45%
946,128	1.600	149.4	Grams	1.19%
946,129	1.800	575.2	Grams	4.57%
946,130	2.000	678.8	Grams	5.39%
946,131	SINK	11,100.3	Grams	88.16%
TOTAL		12,591.6	Grams	100.00%

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	6,174.7	Grams			
LOSS:	14.2	Grams	or	0.23	%

LAB #	GRAVITY	WT	Units	WT%
947,863	1.300	21.1	Grams	0.34%
947,864	1.350	8.3	Grams	0.13%
947,865	1.400	6.5	Grams	0.11%
947,866	1.425	3.1	Grams	0.05%
947,867	1.450	3.3	Grams	0.05%
947,868	1.475	4.9	Grams	0.08%
947,869	1.500	9.2	Grams	0.15%
947,870	1.525	16.9	Grams	0.27%
947,871	1.550	22.1	Grams	0.36%
947,872	1.600	72.1	Grams	1.17%
947,873	1.800	359.4	Grams	5.83%
947,874	2.000	405.1	Grams	6.58%
947,875	SINK	5,228.5	Grams	84.87%
TOTAL		6,160.5	Grams	100.00%

PLANT C

HMC PERFORMANCE TEST - JUNE 18, 2001

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	1,361.5	Grams			
LOSS:	5.0	Grams	or	0.37	%

LAB #	GRAVITY	WT	Units	WT%
948,208	1.300	58.6	Grams	4.32%
948,209	1.400	22.5	Grams	1.66%
948,210	1.450	6.7	Grams	0.49%
948,211	1.500	5.1	Grams	0.38%
948,212	1.550	10.0	Grams	0.74%
948,213	1.600	11.9	Grams	0.88%
948,214	1.700	34.4	Grams	2.54%
948,215	1.800	36.4	Grams	2.68%
948,216	1.900	43.3	Grams	3.19%
948,217	2.000	43.1	Grams	3.18%
948,218	SINK	1,084.5	Grams	79.95%
TOTAL		1,356.5	Grams	100.00%

APPENDIX II-D

Partitioning Data for Plant D

Test Description: CIRCUIT D - COARSE COAL HMC CIRCUIT

Feed Coal Type:	Cedar Grove/Pond Creek			Plant Feed Rate (tph):	1200	Tracer Size (mm): 16
				Circuit Feed Rate(tph):	262	Tracer Shape: Cubes
	Body	Vortex	Apex			
Manufacturer:	Multotec	Multotec	Multotec	Inlet Pressure (psi):	15	Weighting (Y/N)? N
Diameter (Inch):	31.5	13.6	10.8	Gauge Position (inch):	-71	SG Cutpoint (SG50) 1.603
Wear Condition:	N/A	N/A	N/A	Head (Diameters):	6.1 LOW!	Probable Error (Ep): 0.014
Part Alignment:			N/A	Magnetite Grade:	B	Low SG Offset: 0.040

Tracer	Tracer	Overflow (Clean Coal)							Underflow (Refuse)							Tracers	Tracers	Refuse	Fitted	Weight	Weighted
SG	in Feed	A	B	C	D	E	F	Sum	A	B	C	D	E	F	Sum	Collected	Lost	Partition	Partition	Factor	Error
1.50	40	14	5	3	6			28	0	2					2	0.75	0.25	0.07	0.04	0.10	0.00
1.52	40	10	4	6	9			29	0	0					0	0.73	0.28	0.00	0.04	0.10	0.00
1.54	40	10	1	6	9			26	0	1					1	0.68	0.33	0.04	0.05	0.10	0.00
1.56	40	9	2	5	9			25	0	2					2	0.68	0.33	0.07	0.08	0.10	0.00
1.58	40	7	5	3	12			27	2	7					9	0.90	0.10	0.25	0.18	0.25	0.00
1.60	40	8	2	2	6			18	3	10					13	0.78	0.23	0.42	0.47	0.42	0.00
1.62	40	1	2	0	4			7	11	18					29	0.90	0.10	0.81	0.80	0.19	0.00
1.64	40	0	0	0	0			0	8	29					37	0.93	0.08	1.00	0.95	0.10	0.00
1.66	40	0	0	0	0			0	14	19					33	0.83	0.18	1.00	0.99	0.10	0.00
1.68	40	0	0	0	0			0	8	30					38	0.95	0.05	1.00	1.00	0.10	0.00
1.70	40	0	1	0	0			1	7	26					33	0.85	0.15	0.97	1.00	0.10	0.00
Known Dropped		4	2	1	6			13	4	4					8					Total WSSQ:	0.01

Description: CIRCUIT D - COARSE COAL HMC CIRCUIT

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections Real World	O&M Factors	Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1.5	0.01	0.014
16	8	11.31	0.003	1.5	1.5	0.01	0.017
8	4	5.66	0.007	1.5	1.5	0.01	0.025
4	2	2.83	0.013	1.5	1.5	0.01	0.039
2	1	1.41	0.026	1.5	1.5	0.01	0.069
1	0.5	0.71	0.052	1.5	1.5	0.01	0.128

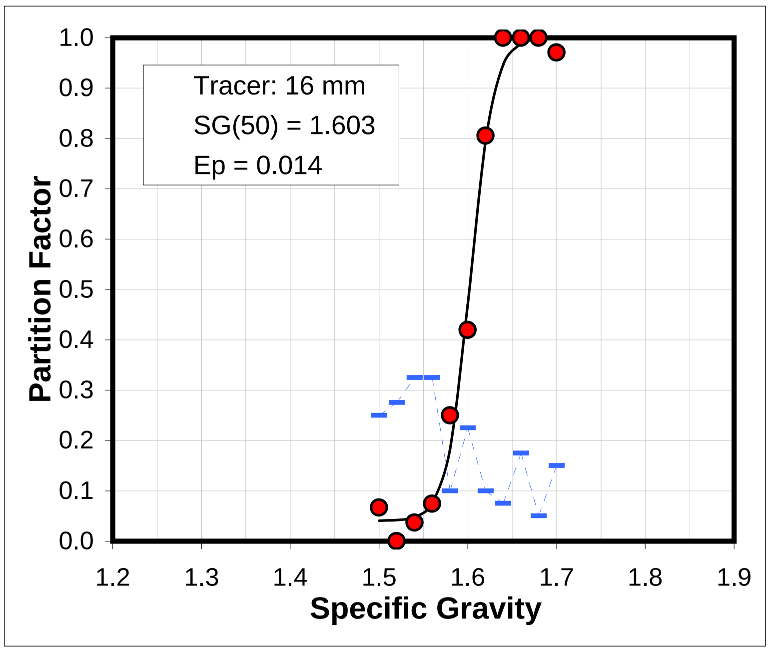
Comments: O&M correction for low pressure.

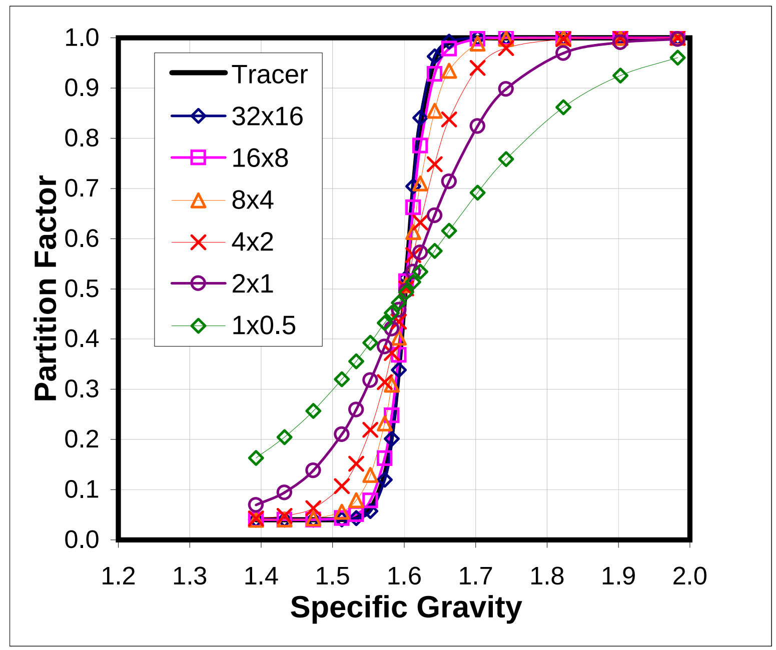
	SG	Split
O/F:	1.478	0.532
U/F:	1.675	0.468
Feed:	1.570	1.000

	SG	Split
Pivot:	1.601	0.468
O/F-U/F	0.20	

Obs.	Marcy Scale SG Feed	O/F	U/F
1	1.57	1.47	1.67
2		1.48	1.68
3		1.47	
4		1.49	
5			
Avg.	1.570	1.478	1.675

Size	16	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.603	1.603	1.603	1.604	1.606	1.609	1.616
Ep	0.014	0.014	0.017	0.025	0.039	0.069	0.13
Offset	0.040	0.040	0.040	0.040	0.040	0.040	0.040





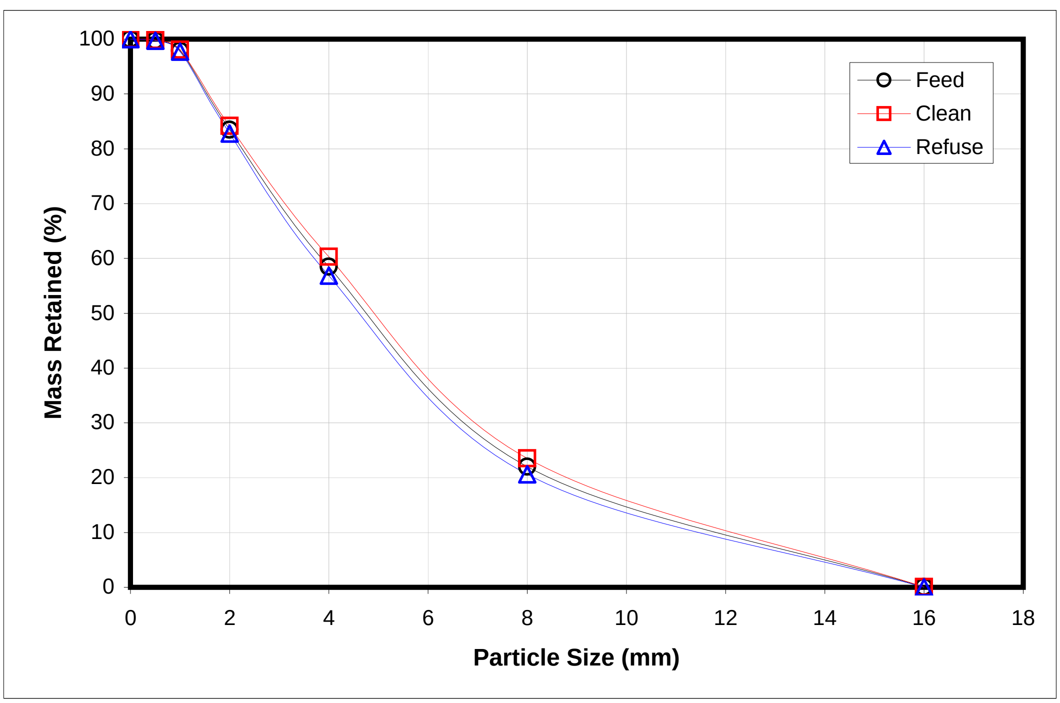
Note: Dashed line represents lost tracers.

Circuit:	CIRCUIT D - COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	126.3	Clean Yield (%):	48.20
Refuse Rate (t/hr):	135.7	Refuse Yield (%):	51.80
Feed Rate (t/hr):	262.0		

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	0.05	10.21	0.03	80.59	0.04	36.48
16	8	11.31	23.45	6.85	20.59	82.14	21.97	43.41
8	4	5.66	36.80	6.85	36.23	82.46	36.51	45.72
4	2	2.83	23.88	6.17	25.94	82.59	24.95	47.33
2	1	1.41	13.89	6.26	14.91	82.14	14.42	46.91
1	0.5	0.71	1.73	5.94	2.01	78.80	1.87	46.39
0.5	0.001	0.02	0.20	23.03	0.29	80.22	0.25	57.45
		Totals	100.00	6.62	100.00	82.30	100.00	45.82

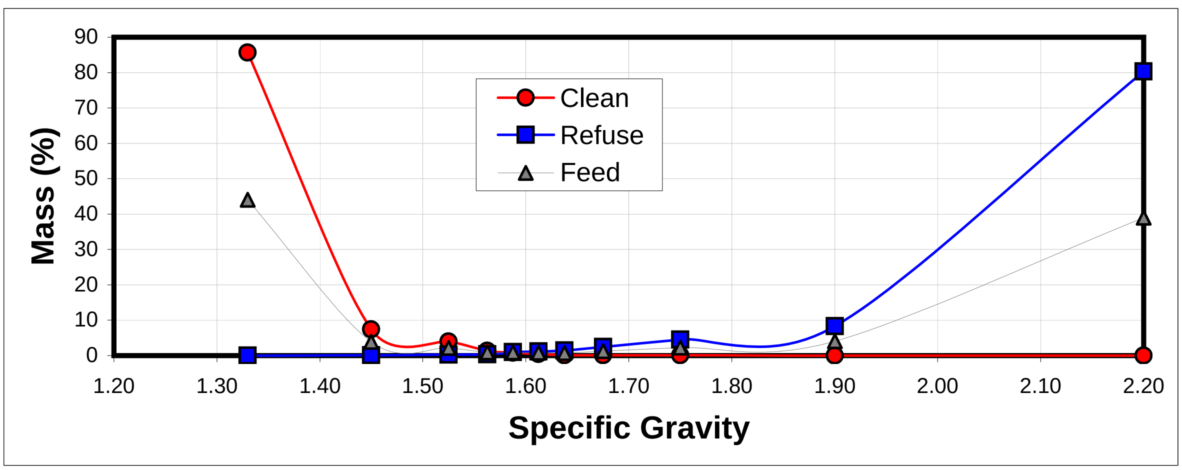
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	62.67	37.33	100.00	0.05	0.03	0.04
16	8	11.31	51.44	48.56	100.00	23.50	20.62	22.01
8	4	5.66	48.59	51.41	100.00	60.30	56.85	58.51
4	2	2.83	46.14	53.86	100.00	84.18	82.79	83.46
2	1	1.41	46.43	53.57	100.00	98.07	97.71	97.88
1	0.5	0.71	44.48	55.52	100.00	99.80	99.71	99.75
0.5	0.001	0.02	39.81	60.19	100.00	100.00	100.00	100.00
		Totals	48.20	51.80	100.00			

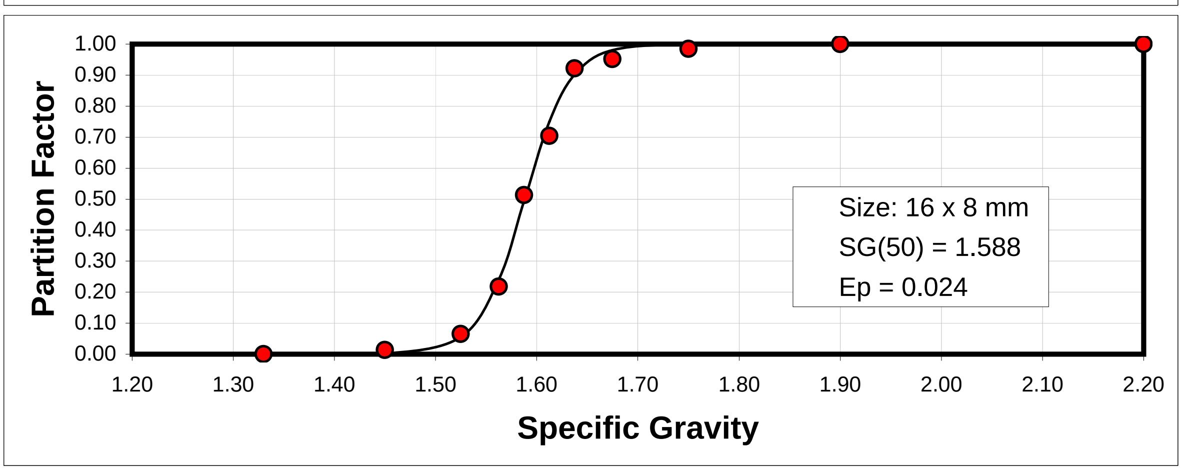


Circuit:	CIRCUIT D - COARSE COAL HMC CIRCUIT
Size:	16 x 8 mm

Clean Yield (%)	51.44	SG Cutpoint (SG50)	1.588	Weighting (Y/N)?	Y
Refuse Yield (%)	48.56	Probable Error (Ep):	0.024	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	85.67	0.02	44.08	0.00	0.00	0.10	0.00
1.400	1.500	1.450	7.43	0.10	3.88	0.01	0.00	0.10	0.01
1.500	1.550	1.525	3.96	0.29	2.18	0.07	0.06	0.10	0.01
1.550	1.575	1.563	1.33	0.39	0.88	0.22	0.24	0.22	0.01
1.575	1.600	1.588	0.86	0.96	0.90	0.51	0.49	0.49	0.00
1.600	1.625	1.613	0.45	1.13	0.78	0.70	0.75	0.30	0.02
1.625	1.650	1.638	0.12	1.44	0.76	0.92	0.90	0.10	0.04
1.650	1.700	1.675	0.12	2.48	1.27	0.95	0.98	0.10	0.08
1.700	1.800	1.750	0.07	4.55	2.24	0.98	1.00	0.10	0.02
1.800	2.000	1.900	0.00	8.29	4.03	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.00	80.34	39.01	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.20

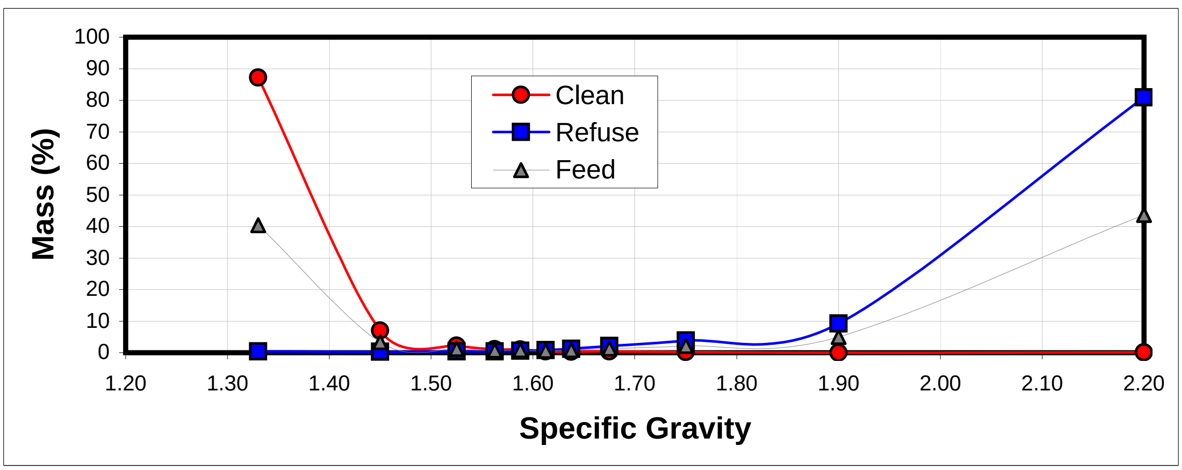


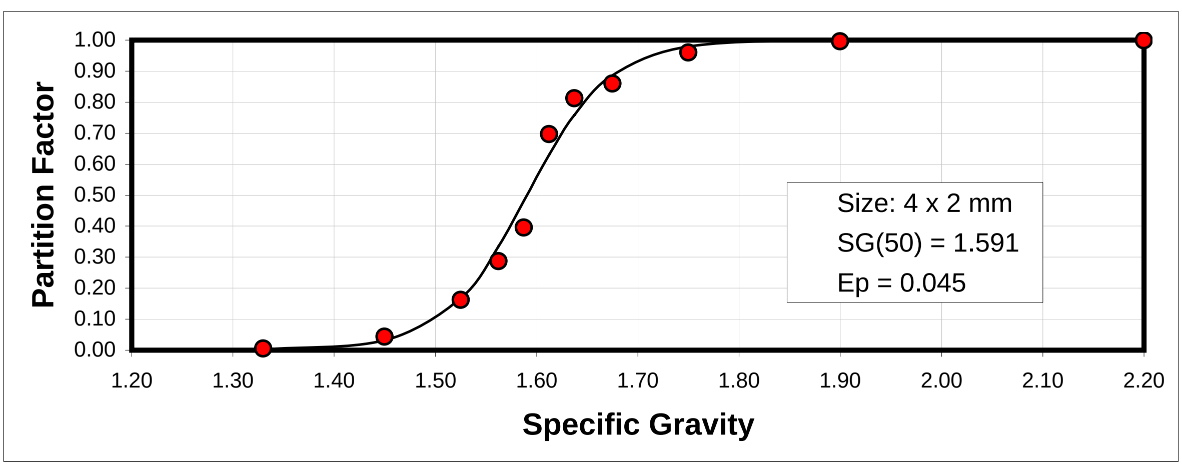


Circuit:	CIRCUIT D - COARSE COAL HMC CIRCUIT
Size:	4 x 2 mm

Clean Yield (%)	46.14	SG Cutpoint (SG50)	1.591	Weighting (Y/N)?	Y
Refuse Yield (%)	53.86	Probable Error (Ep):	0.045	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	87.17	0.38	40.42	0.01	0.00	0.10	0.00
1.400	1.500	1.450	7.03	0.27	3.39	0.04	0.03	0.10	0.01
1.500	1.550	1.525	2.25	0.37	1.24	0.16	0.17	0.16	0.00
1.550	1.575	1.563	1.07	0.37	0.69	0.29	0.34	0.29	0.03
1.575	1.600	1.588	1.02	0.57	0.78	0.40	0.48	0.40	0.05
1.600	1.625	1.613	0.39	0.76	0.59	0.70	0.63	0.30	0.05
1.625	1.650	1.638	0.32	1.17	0.78	0.81	0.76	0.19	0.08
1.650	1.700	1.675	0.40	2.12	1.33	0.86	0.89	0.14	0.04
1.700	1.800	1.750	0.19	3.83	2.15	0.96	0.98	0.10	0.04
1.800	2.000	1.900	0.05	9.21	4.99	1.00	1.00	0.10	0.00
2.000	2.400	2.200	0.12	80.94	43.65	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.30

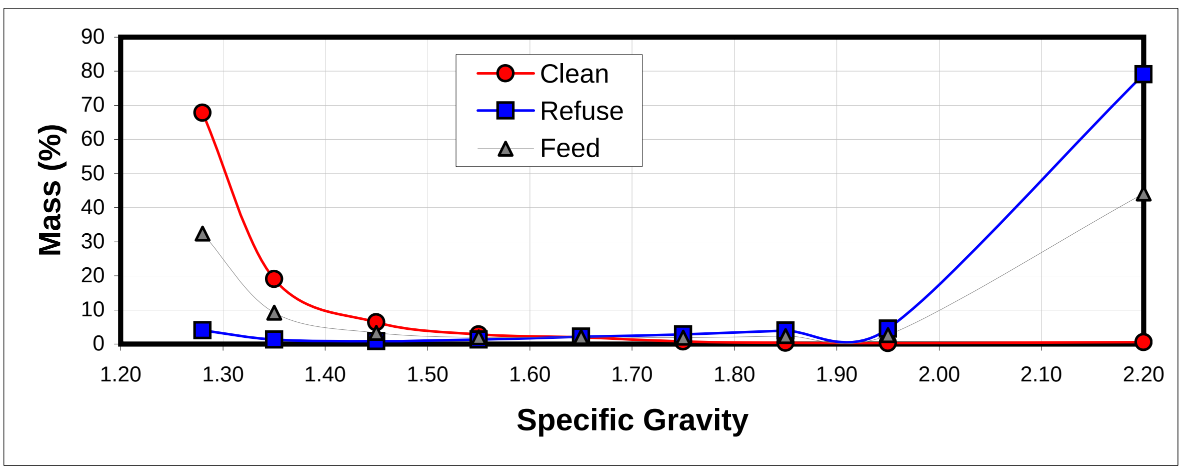


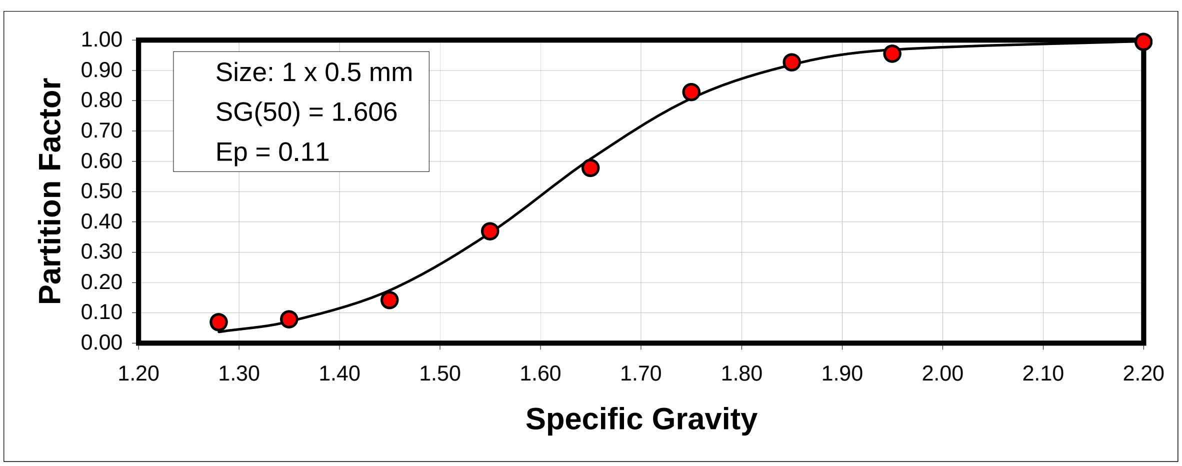


Circuit:	CIRCUIT D - COARSE COAL HMC CIRCUIT
Size:	1 x 0.5 mm

Clean Yield (%)	44.48	SG Cutpoint (SG50)	1.606	Weighting (Y/N)?	Y
Refuse Yield (%)	55.52	Probable Error (Ep):	0.110	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	67.80	4.02	32.39	0.07	0.04	0.10	0.10
1.300	1.400	1.350	19.07	1.30	9.20	0.08	0.07	0.10	0.00
1.400	1.500	1.450	6.38	0.84	3.31	0.14	0.17	0.14	0.05
1.500	1.600	1.550	2.78	1.30	1.96	0.37	0.36	0.37	0.00
1.600	1.700	1.650	1.97	2.16	2.07	0.58	0.61	0.42	0.01
1.700	1.800	1.750	0.74	2.83	1.90	0.83	0.81	0.17	0.01
1.800	1.900	1.850	0.39	3.97	2.38	0.93	0.92	0.10	0.01
1.900	2.000	1.950	0.26	4.47	2.60	0.96	0.97	0.10	0.02
2.000	2.400	2.200	0.60	79.11	44.19	0.99	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.20

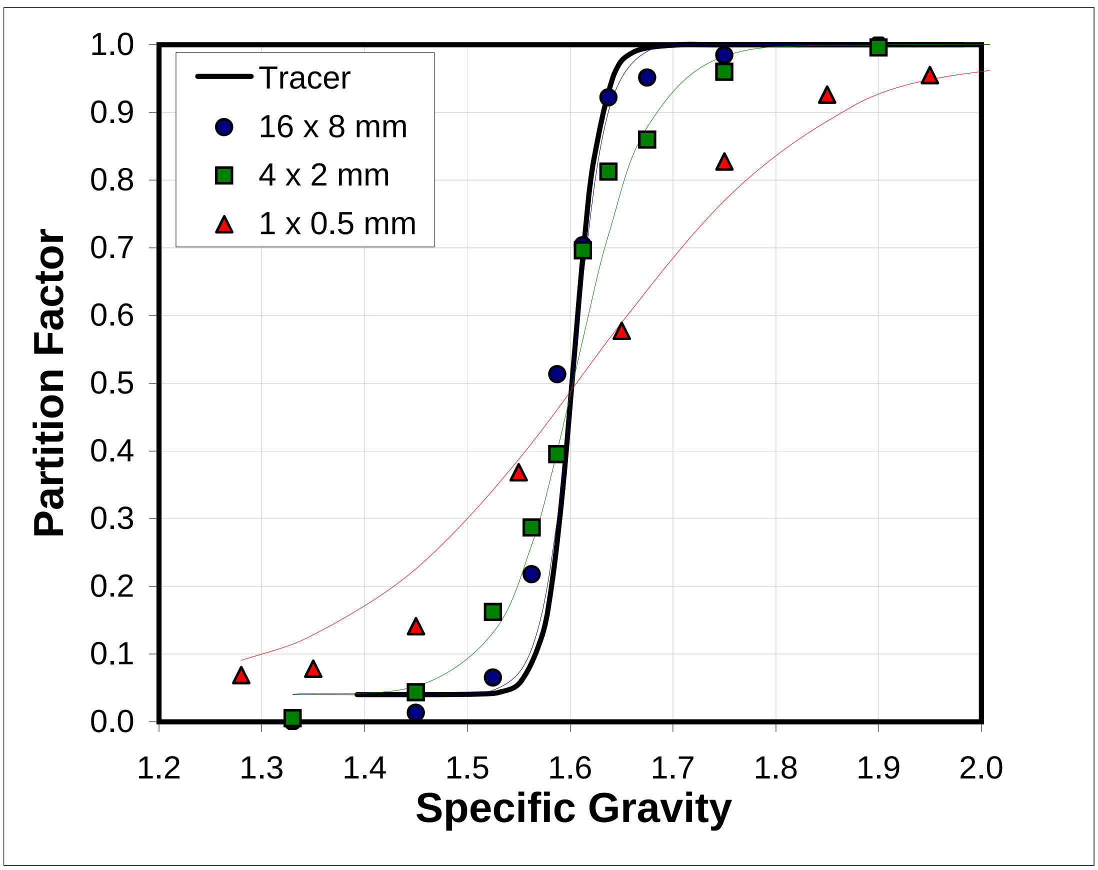


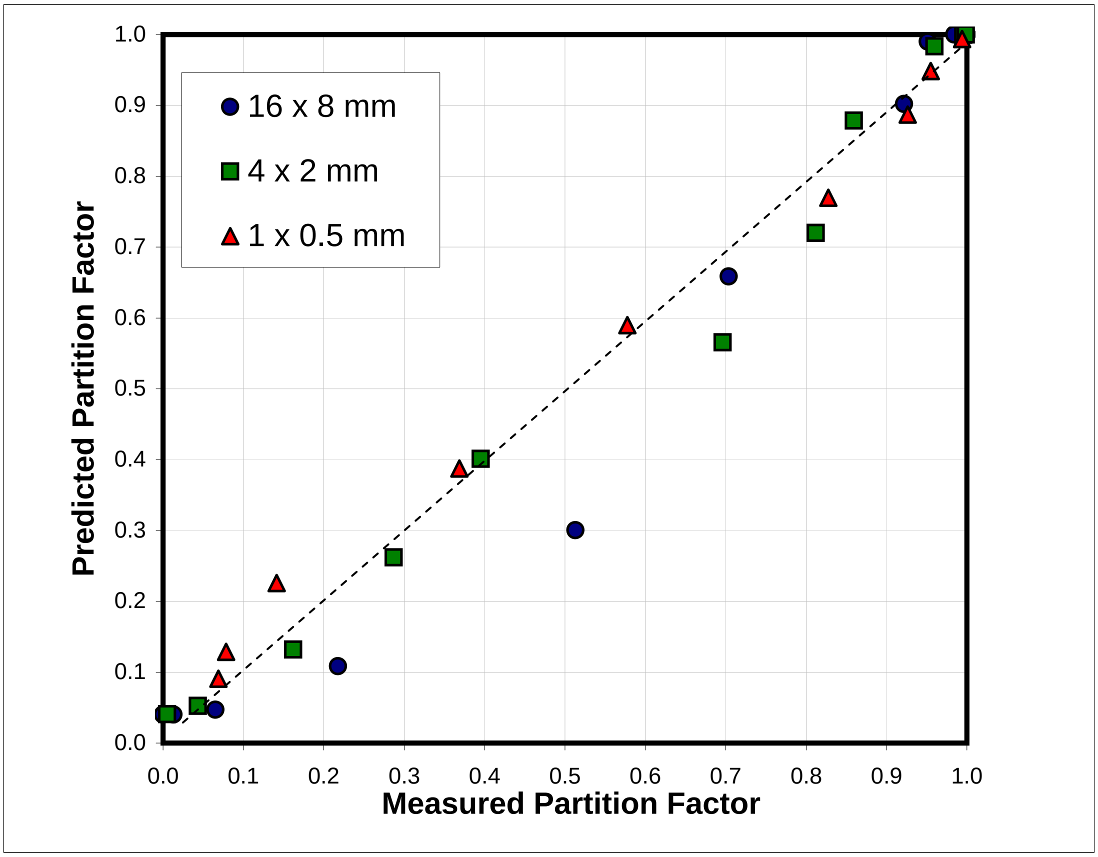


Circuit: CIRCUIT D - COARSE COAL HMC CIRCUIT

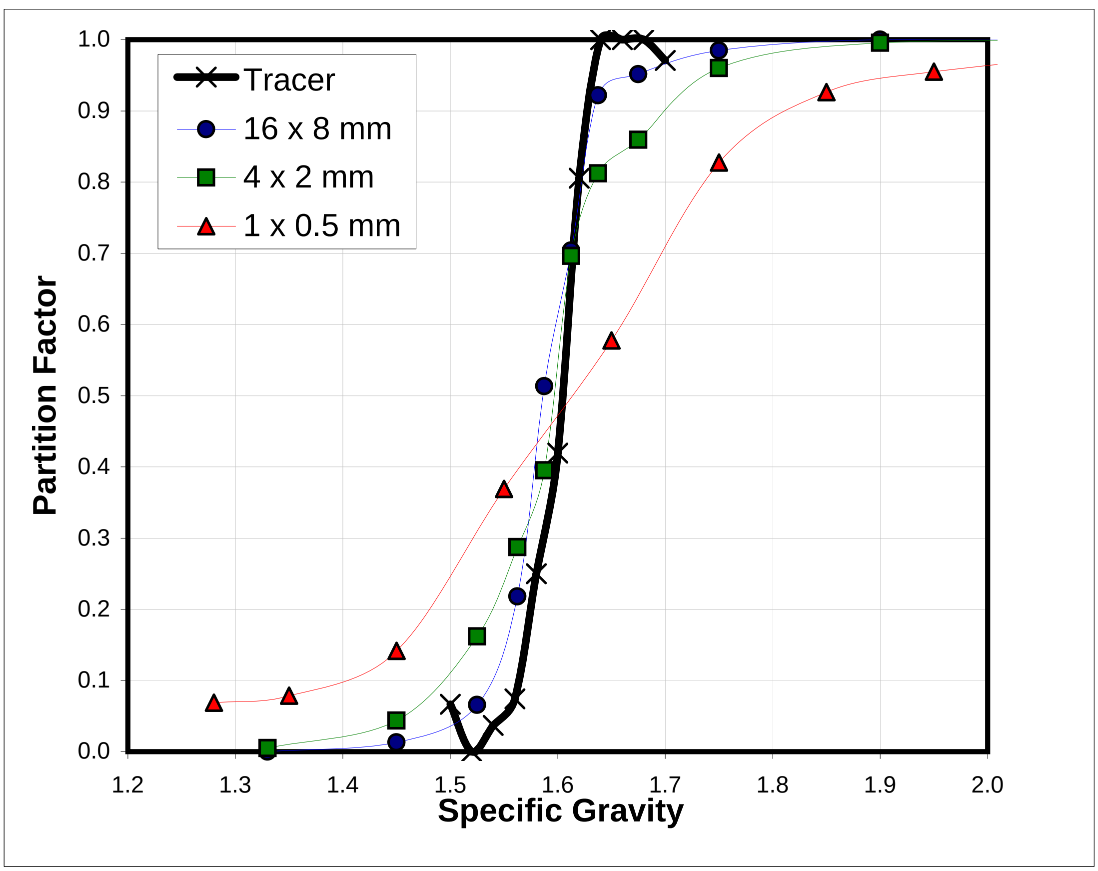
	Measured 16 x 8 mm	Predicted 16 x 8 mm		Measured 4 x 2 mm	Predicted 4 x 2 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.588	1.603	SG(50):	1.591	1.606	SG(50):	1.606	1.616
Ep:	0.024	0.017	Ep:	0.045	0.039	Ep:	0.110	0.128
Offset:	0.000	0.040	Offset:	0.000	0.040	Offset:	0.000	0.040

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16 x 8 mm	Predicted 16 x 8 mm	SG	Measured 4 x 2 mm	Predicted 4 x 2 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.33	0.00	0.040	1.33	0.01	0.040	1.28	0.07	0.091
1.45	0.01	0.040	1.45	0.04	0.052	1.35	0.08	0.129
1.53	0.07	0.047	1.53	0.16	0.132	1.45	0.14	0.226
1.56	0.22	0.108	1.56	0.29	0.262	1.55	0.37	0.388
1.59	0.51	0.300	1.59	0.40	0.401	1.65	0.58	0.590
1.61	0.70	0.658	1.61	0.70	0.566	1.75	0.83	0.770
1.64	0.92	0.902	1.64	0.81	0.720	1.85	0.93	0.887
1.68	0.95	0.990	1.68	0.86	0.878	1.95	0.96	0.949
1.75	0.98	1.000	1.75	0.96	0.983	2.20	0.99	0.994
1.90	1.00	1.000	1.90	1.00	1.000			
2.20	1.00	1.000	2.20	1.00	1.000			





Predicted Partition Factor
Measured Partition Factor
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0



Partition Factor
Specific Gravity
Tracer
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0

CIRCUIT D - HMC PERFORMANCE TEST
SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT	AIR DRY MOISTURE
FEED	#1	1 OF 4	17,925.0	920.4	15,431.0	17,004.6	14,510.6	14.67%
FEED	#1	2 OF 4	17,856.6	1,042.5	15,377.7	16,814.1	14,335.2	14.74%
FEED	#1	3 OF 4	19,617.7	921.4	17,167.2	18,696.3	16,245.8	13.11%
FEED	#1	4 OF 4	20,172.2	1,012.1	18,392.8	19,160.1	17,380.7	9.29%
TOTAL FEED	#1	4	75,571.5	3,896.4	66,368.7	71,675.1	62,472.3	12.84%
CLEAN COAL	#1	1 OF 1	17,014.8	993.8	14,536.7	16,021.0	13,542.9	15.47%
CLEAN COAL	#2	1 OF 1	11,667.9	1,036.3	10,261.3	10,631.6	9,225.0	13.23%
CLEAN COAL	#3	1 OF 1	6,272.3	913.7	5,427.6	5,358.6	4,513.9	15.76%
CLEAN COAL	#4	1 OF 1	8,813.7	996.1	7,448.6	7,817.6	6,452.5	17.46%
TOTAL CLEAN	#1 - #4	4	43,768.7	3,939.9	37,674.2	39,828.8	33,734.3	15.30%
REFUSE	#1	1 OF 2	11,304.1	917.7	10,265.9	10,386.4	9,348.2	10.00%
REFUSE	#1	2 OF 2	13,815.4	1,010.7	12,300.3	12,804.7	11,289.6	11.83%
SUBTOTAL REF	#1	2	25,119.5	1,928.4	22,566.2	23,191.1	20,637.8	11.01%
REFUSE	#2	1 OF 2	27,612.3	1,049.4	25,229.7	26,562.9	24,180.3	8.97%
REFUSE	#2	2 OF 2	24,017.6	898.3	22,068.6	23,119.3	21,170.3	8.43%
SUBTOTAL REF	#2	2	51,629.9	1,947.7	47,298.3	49,682.2	45,350.6	8.72%

CIRCUIT D - HMC PERFORMANCE TEST
MEDIA SAMPLES

FEED MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	5,336.5	TARE WT.	691.1
SOLIDS WT.	2,184.3	% SOLIDS	47.02%
LAB NO.	SIZE	WT (Grams)	WT %
944,212	+ 25M	21.2	0.97%
944,213	25M x 0	2,163.1	99.03%
	Totals	2,184.3	100.00%

CLEAN COAL #1 & #2 MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	9,049.9	TARE WT.	421.7
SOLIDS WT.	3,700.5	% SOLIDS	42.89%
LAB NO.	SIZE	WT (Grams)	WT %
944,214	+ 25M	67.6	1.83%
944,215	25M x 0	3,632.9	98.17%
	Totals	3,700.5	100.00%

CLEAN COAL #3 & #4 MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	9,133.9	TARE WT.	416.9
SOLIDS WT.	3,678.7	% SOLIDS	42.20%
LAB NO.	SIZE	WT (Grams)	WT %
944,216	+ 25M	23.0	0.63%
944,217	25M x 0	3,655.7	99.37%
	Totals	3,678.7	100.00%

REFUSE #1 MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	5,349.6	TARE WT.	415.1
SOLIDS WT.	2,528.2	% SOLIDS	51.24%
LAB NO.	SIZE	WT (Grams)	WT %
944,218	+ 25M	6.9	0.27%
944,219	25M x 0	2,521.3	99.73%
	Totals	2,528.2	100.00%

REFUSE #2 MEDIA

NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns)

HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION

TOTAL WT.	5,369.5	TARE WT.	426.7
SOLIDS WT.	2,534.2	% SOLIDS	51.27%
LAB NO.	SIZE	WT (Grams)	WT %
944,220	+ 25M	12.6	0.50%
944,221	25M x 0	2,521.6	99.50%
	Totals	2,534.2	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 1 of 5

Plant: **CIRCUIT D**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	944,222	**Lab #:**	944,222
Weights	Grams	**Weights**	Grams
Flask	67.1484	**Flask**	63.5994
Flask, Non-Mag, Mags	107.9595	**Flask, Non-Mag, Mags**	103.7343
Flask + Mags	101.0427	**Flask + Mags**	97.5272
% Mags:	83.05%	**% Mags:**	84.53%

RUN AVG:	**83.79%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	944,223	**Lab #:**	944,223
Weights	Grams	**Weights**	Grams
Flask	68.1853	**Flask**	68.3140
Flask, Non-Mag, Mags	108.7479	**Flask, Non-Mag, Mags**	108.6101
Flask + Mags	101.6826	**Flask + Mags**	101.3997
% Mags:	82.58%	**% Mags:**	82.11%

RUN AVG:	**82.34%**

TOT AVG:	**83.07%**

CIRCUIT D - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 2 of 5

Plant: CIRCUIT D

ID:	**CLEAN COAL #1 & #2 MEDIA**	**ID:**	**CLEAN COAL #1 & #2 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	944,224	**Lab #:**	944,224
Weights	Grams	**Weights**	Grams
Flask	63.5083	**Flask**	67.2046
Flask, Non-Mag, Mags	103.5741	**Flask, Non-Mag, Mags**	107.5432
Flask + Mags	94.9238	**Flask + Mags**	99.1684
% Mags:	78.41%	**% Mags:**	79.24%

RUN AVG:	**78.82%**

ID:	**CLEAN COAL #1 & #2 MEDIA**	**ID:**	**CLEAN COAL #1 & #2 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	944,225	**Lab #:**	944,225
Weights	Grams	**Weights**	Grams
Flask	64.6499	**Flask**	67.4879
Flask, Non-Mag, Mags	104.7685	**Flask, Non-Mag, Mags**	107.7244
Flask + Mags	97.5124	**Flask + Mags**	100.1638
% Mags:	81.91%	**% Mags:**	81.21%

RUN AVG:	**81.56%**

TOT AVG:	**80.19%**

CIRCUIT D - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 3 of 5

Plant: **CIRCUIT D**

ID:	**CLEAN COAL #3 & #4 MEDIA**	**ID:**	**CLEAN COAL #3 & #4 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	944,226	**Lab #:**	944,226
Weights	Grams	**Weights**	Grams
Flask	66.3603	**Flask**	68.4208
Flask, Non-Mag, Mags	106.9744	**Flask, Non-Mag, Mags**	108.7102
Flask + Mags	99.7869	**Flask + Mags**	101.8060
% Mags:	82.30%	**% Mags:**	82.86%

RUN AVG:	**82.58%**

ID:	**CLEAN COAL #3 & #4 MEDIA**	**ID:**	**CLEAN COAL #3 & #4 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	944,227	**Lab #:**	944,227
Weights	Grams	**Weights**	Grams
Flask	67.0987	**Flask**	67.3757
Flask, Non-Mag, Mags	107.7158	**Flask, Non-Mag, Mags**	107.7770
Flask + Mags	99.8942	**Flask + Mags**	100.1362
% Mags:	80.74%	**% Mags:**	81.09%

RUN AVG:	**80.92%**

TOT AVG:	**81.75%**

CIRCUIT D - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 4 of 5

Plant:	**CIRCUIT D**		
ID:	**REFUSE #1 MEDIA**	**ID:**	**REFUSE #1 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	944,228	**Lab #:**	944,228
Weights	Grams	**Weights**	Grams
Flask	63.8172	**Flask**	68.1021
Flask, Non-Mag, Mags	103.7533	**Flask, Non-Mag, Mags**	108.7347
Flask + Mags	98.6047	**Flask + Mags**	104.1431
% Mags:	87.11%	**% Mags:**	88.70%

RUN AVG:	**87.90%**

ID:	**REFUSE #1 MEDIA**	**ID:**	**REFUSE #1 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	944,229	**Lab #:**	944,229
Weights	Grams	**Weights**	Grams
Flask	68.0121	**Flask**	67.7145
Flask, Non-Mag, Mags	108.9137	**Flask, Non-Mag, Mags**	107.7343
Flask + Mags	103.8891	**Flask + Mags**	103.6109
% Mags:	87.72%	**% Mags:**	89.70%

RUN AVG:	**88.71%**

TOT AVG:	**88.30%**

CIRCUIT D - HMC PERFORMANCE TEST

MEDIA SAMPLES - PAGE 5 of 5

Plant:	**CIRCUIT D**		
ID:	**REFUSE #2 MEDIA**	**ID:**	**REFUSE #2 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	944,230	**Lab #:**	944,230
Weights	Grams	**Weights**	Grams
Flask	63.7063	**Flask**	65.2377
Flask, Non-Mag, Mags	103.7706	**Flask, Non-Mag, Mags**	105.8739
Flask + Mags	97.9857	**Flask + Mags**	101.3339
% Mags:	85.56%	**% Mags:**	88.83%

RUN AVG:	**87.19%**

ID:	**REFUSE #2 MEDIA**	**ID:**	**REFUSE #2 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	944,231	**Lab #:**	944,231
Weights	Grams	**Weights**	Grams
Flask	68.7422	**Flask**	64.7071
Flask, Non-Mag, Mags	108.7535	**Flask, Non-Mag, Mags**	104.8245
Flask + Mags	103.8553	**Flask + Mags**	99.8912
% Mags:	87.76%	**% Mags:**	87.70%

RUN AVG:	**87.73%**

TOT AVG:	**87.46%**

CIRCUIT D - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all four (4) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	33,734.3	Grams or	74.371	Lbs
START WEIGHT - REWEIGH:	74.4	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
950,859	6.71

Screen Analysis (Using 7 Containers) 65.1 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
950,860	+ 16mm	15.2	Grams	0.05%	10.21
950,861	*16 x 8mm*	6,908.9	Grams	23.45%	6.85
950,862	8 x 4mm	10,843.6	Grams	36.80%	6.85
Totals	**+4mm**	**17,767.7**	**Grams**	**60.30%**	**6.85**

Total +4mm Wt	17,767.7	Grams	60.30%			
Total -4mm Wt	11,699.7	Grams	39.70%			
Total Wt	29,467.4	Grams	100.00%	or	65.0	Lbs
Screen Loss	61.5	Grams		or	0.21	%
-4mm Split Wt	11,699.7	Grams	(Use All)			
Screen Loss	12.9	Grams		or	0.11	%
Total Scr Loss	74.4	Grams		or	0.25	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
950,863	*4 x 2mm*	7,029.3	Grams	23.88%	6.17
950,864	2 x 1mm	4,089.6	Grams	13.89%	6.26
950,865	*1 x 0.5mm*	508.2	Grams	1.73%	5.94
950,866	0.5mm x 0	59.7	Grams	0.20%	23.03
Totals	**4mm x 0**	**11,686.8**	**Grams**	**39.70%**	**6.28**
Totals	**+16mm x 0**	**29,454.5**	**Grams**	**100.00%**	**6.62**

CIRCUIT D - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	5,210.9	Grams			
LOSS:	11.9	Grams	or	0.23	%

LAB #	GRAVITY	WT	Units	WT%
959,277	1.400	4,453.9	Grams	85.67%
959,278	1.500	386.5	Grams	7.43%
959,279	1.550	205.8	Grams	3.96%
959,280	1.575	69.2	Grams	1.33%
959,281	1.600	44.5	Grams	0.86%
959,282	1.625	23.4	Grams	0.45%
959,283	1.650	6.0	Grams	0.12%
959,284	1.700	6.2	Grams	0.12%
959,285	1.800	3.5	Grams	0.07%
	2.000	0.0	Grams	0.00%
	SINK	0.0	Grams	0.00%
TOTAL		5,199.0	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	5,258.2	Grams			
LOSS:	66.2	Grams	or	1.26	%

LAB #	GRAVITY	WT	Units	WT%
965,589	1.400	4,525.9	Grams	87.17%
965,590	1.500	365.0	Grams	7.03%
965,591	1.550	116.8	Grams	2.25%
965,592	1.575	55.4	Grams	1.07%
965,593	1.600	52.8	Grams	1.02%
965,594	1.625	20.2	Grams	0.39%
965,595	1.650	16.4	Grams	0.32%
965,596	1.700	21.0	Grams	0.40%
965,597	1.800	9.7	Grams	0.19%
965,598	2.000	2.5	Grams	0.05%
965,599	SINK	6.3	Grams	0.12%
TOTAL		5,192.0	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	384.6	Grams			
LOSS:	3.8	Grams	or	0.99	%

LAB #	GRAVITY	WT	Units	WT%
966,693	1.300	258.2	Grams	67.80%
966,694	1.400	72.6	Grams	19.07%
966,695	1.500	24.3	Grams	6.38%
966,696	1.600	10.6	Grams	2.78%
966,697	1.700	7.5	Grams	1.97%
966,698	1.800	2.8	Grams	0.74%
966,699	1.900	1.5	Grams	0.39%
966,700	2.000	1.0	Grams	0.26%
966,701	SINK	2.3	Grams	0.60%
TOTAL		380.8	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all four (4) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	65,988.4	Grams or	145.480	Lbs
START WEIGHT - REWEIGH:	145.5	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
950,867	82.02

Screen Analysis (Using 7 Containers) 127.5 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
950,868	+ 16mm	16.5	Grams	0.03%	80.59
950,869	*16 x 8mm*	11,884.1	Grams	20.59%	82.14
950,870	8 x 4mm	20,910.6	Grams	36.23%	82.46
Totals	+4mm	32,811.2	Grams	56.85%	82.34

Total +4mm Wt	32,811.2	Grams	56.85%			
Total -4mm Wt	24,902.2	Grams	43.15%			
Total Wt	57,713.5	Grams	100.00%	or	127.2	Lbs
Screen Loss	119.6	Grams		or	0.21	%
-4mm Split Wt	24,902.2	Grams	(Use All)			
Screen Loss	119.7	Grams		or	0.48	%
Total Scr Loss	239.3	Grams		or	0.41	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
950,871	*4 x 2mm*	14,900.5	Grams	25.94%	82.59
950,872	2 x 1mm	8,566.3	Grams	14.91%	82.14
950,873	*1 x 0.5mm*	1,151.8	Grams	2.01%	78.80
950,874	0.5mm x 0	163.9	Grams	0.29%	80.22
Totals	4mm x 0	24,782.5	Grams	43.15%	82.24
Totals	+16mm x 0	57,593.7	Grams	100.00%	82.30

CIRCUIT D - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	8,820.7	Grams			
LOSS:	35.9	Grams	or	0.41	%

LAB #	GRAVITY	WT	Units	WT%
967,020	1.400	1.4	Grams	0.02%
967,021	1.500	9.2	Grams	0.10%
967,022	1.550	25.8	Grams	0.29%
967,023	1.575	34.5	Grams	0.39%
967,024	1.600	84.0	Grams	0.96%
967,025	1.625	99.5	Grams	1.13%
967,026	1.650	126.8	Grams	1.44%
967,027	1.700	217.8	Grams	2.48%
967,028	1.800	399.9	Grams	4.55%
967,029	2.000	728.5	Grams	8.29%
967,030	SINK	7,057.4	Grams	80.34%
TOTAL		8,784.8	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	11,233.9	Grams			
LOSS:	7.1	Grams	or	0.06	%

LAB #	GRAVITY	WT	Units	WT%
967,944	1.400	42.4	Grams	0.38%
967,945	1.500	30.8	Grams	0.27%
967,946	1.550	41.8	Grams	0.37%
967,947	1.575	41.3	Grams	0.37%
967,948	1.600	63.9	Grams	0.57%
967,949	1.625	85.8	Grams	0.76%
967,950	1.650	131.4	Grams	1.17%
967,951	1.700	237.8	Grams	2.12%
967,952	1.800	430.1	Grams	3.83%
967,953	2.000	1,034.5	Grams	9.21%
967,954	SINK	9,087.0	Grams	80.94%
TOTAL		11,226.8	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	872.4	Grams			
LOSS:	5.2	Grams	or	0.60	%

LAB #	GRAVITY	WT	Units	WT%
967,031	1.300	34.9	Grams	4.02%
967,032	1.400	11.3	Grams	1.30%
967,033	1.500	7.3	Grams	0.84%
967,034	1.600	11.3	Grams	1.30%
967,035	1.700	18.7	Grams	2.16%
967,036	1.800	24.5	Grams	2.83%
967,037	1.900	34.4	Grams	3.97%
967,038	2.000	38.8	Grams	4.47%
967,039	SINK	686.0	Grams	79.11%
TOTAL		867.2	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC FEED SAMPLE - SCREEN ANALYSIS

Combine all four (4) feed samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	62,472.3	Grams or	137.728	Lbs
START WEIGHT - REWEIGH:	135.6	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
950,506	45.52

Screen Analysis (Using 7 Containers) 118.7 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
950,507	+ 16mm	28.0	Grams	0.05%	28.36
950,508	*16 x 8mm*	11,838.8	Grams	22.01%	44.76
950,509	8 x 4mm	19,187.0	Grams	35.68%	46.33
Totals	+4mm	31,053.7	Grams	57.74%	45.72

Total +4mm Wt	31,053.7	Grams	57.74%			
Total -4mm Wt	22,725.0	Grams	42.26%			
Total Wt	53,778.7	Grams	100.00%	or	118.6	Lbs
Screen Loss	62.7	Grams		or	0.12	%
-4mm Split Wt	22,725.0	Grams	(Use All)			
Screen Loss	138.3	Grams		or	0.61	%
Total Scr Loss	201.0	Grams		or	0.37	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
950,510	*4 x 2mm*	13,260.7	Grams	24.81%	45.30
950,511	2 x 1mm	7,158.7	Grams	13.39%	44.89
950,512	*1 x 0.5mm*	1,418.0	Grams	2.65%	41.02
950,513	0.5mm x 0	749.3	Grams	1.40%	45.96
Totals	4mm x 0	22,586.7	Grams	42.26%	44.92
Totals	+16mm x 0	53,640.4	Grams	100.00%	45.38

CIRCUIT D - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	8,971.9	Grams			
LOSS:	12.8	Grams	or	0.14	%

LAB #	GRAVITY	WT	Units	WT%
951,756	1.400	3,959.8	Grams	44.20%
951,757	1.500	348.8	Grams	3.89%
951,758	1.550	144.6	Grams	1.61%
951,759	1.575	87.8	Grams	0.98%
951,760	1.600	65.5	Grams	0.73%
951,761	1.625	87.4	Grams	0.98%
951,762	1.650	55.9	Grams	0.62%
951,763	1.700	84.0	Grams	0.94%
951,764	1.800	154.1	Grams	1.72%
951,765	2.000	431.3	Grams	4.81%
951,766	SINK	3,539.9	Grams	39.51%
TOTAL		8,959.1	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	9,992.9	Grams			
LOSS:	2.8	Grams	or	0.03	%

LAB #	GRAVITY	WT	Units	WT%
951,756	1.400	4,318.1	Grams	43.22%
951,757	1.500	281.7	Grams	2.82%
951,758	1.550	151.3	Grams	1.51%
951,759	1.575	73.3	Grams	0.73%
951,760	1.600	56.2	Grams	0.56%
951,761	1.625	58.9	Grams	0.59%
951,762	1.650	50.9	Grams	0.51%
951,763	1.700	87.9	Grams	0.88%
951,764	1.800	231.8	Grams	2.32%
951,765	2.000	459.3	Grams	4.60%
951,766	SINK	4,220.7	Grams	42.25%
TOTAL		9,990.1	Grams	100.00%

CIRCUIT D - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	1,078.3	Grams			
LOSS:	0.1	Grams	or	0.01	%

LAB #	GRAVITY	WT	Units	WT%
957,289	1.300	412.5	Grams	38.26%
957,290	1.400	101.1	Grams	9.38%
957,291	1.500	32.2	Grams	2.99%
957,292	1.600	24.6	Grams	2.28%
957,293	1.700	19.0	Grams	1.76%
957,294	1.800	17.7	Grams	1.64%
957,295	1.900	21.7	Grams	2.01%
957,296	2.000	23.6	Grams	2.19%
957,297	SINK	425.8	Grams	39.49%
TOTAL		1,078.2	Grams	100.00%

APPENDIX II-E

Partitioning Data for Plant E

Test Description:	CIRCUIT E - COARSE COAL HMC CIRCUIT			
Feed Coal Type:	Feeder #5 Strip Coal	Plant Feed Rate (tph): 810		Tracer Size (mm): 32
		Circuit Feed Rate(tph): 225		Tracer Shape: Cubes

	Body	Vortex	Apex				
Manufacturer:	wormsc	wormsc	wormsc	Inlet Pressure (psi):	11.3	Weighting (Y/N)?	N
Diameter (Inch):	28	12	3.94-9.09	Gauge Position (inch):	44	SG Cutpoint (SG50)	1.648
Wear Condition:	Good	Good	Good	Head (Diameters):	9.4	Probable Error (Ep):	0.021
Part Alignment:			Good	Magnetite Grade:	B	Low SG Offset:	0.000

Tracer SG	Tracer in Feed	Overflow (Clean Coal) A	B	C	D	E	F	Sum	Underflow (Refuse) A	B	C	D	E	F	Sum	Tracers Collected	Tracers Lost	Refuse Partition	Fitted Partition	Weight Factor	Weighted Error
1.50	20	9	7					16	0						0	0.80	0.20	0.00	0.00	0.10	0.00
1.52	20	6	9					15	0						0	0.75	0.25	0.00	0.00	0.10	0.00
1.54	20	8	9					17	0						0	0.85	0.15	0.00	0.00	0.10	0.00
1.56	20	6	8					14	0						0	0.70	0.30	0.00	0.01	0.10	0.00
1.58	20	7	11					18	0						0	0.90	0.10	0.00	0.03	0.10	0.00
1.60	20	6	9					15	0						0	0.75	0.25	0.00	0.07	0.10	0.01
1.62	20	6	9					15	5						5	1.00	0.00	0.25	0.19	0.25	0.00
1.64	20	1	10					11	8						8	0.95	0.05	0.42	0.40	0.42	0.00
1.66	20	0	7					7	11						11	0.90	0.10	0.61	0.66	0.39	0.00
1.68	20	0	1					1	5						5	0.30	0.70	0.83	0.85	0.17	0.00
1.70	20	0	0					0	10						10	0.50	0.50	1.00	0.94	0.10	0.00
1.72	5	0	0					0	4						4	0.80	0.20	1.00	0.98	0.10	0.00
1.74	5	0	0					0	4						4	0.80	0.20	1.00	0.99	0.10	0.00
1.76	5	0	0					0	5						5	1.00	0.00	1.00	1.00	0.10	0.00
1.78	5	0	0					0	5						5	1.00	0.00	1.00	1.00	0.10	0.00
Known Dropped		9	4					13	2						2					Total WSSQ:	0.02

Description: CIRCUIT E - COARSE COAL HMC CIRCUIT

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Predict Ep (Wood)	Ep Corrections Real World	O&M Factors	Diff. Cut	Expect Ep Value
32	16	22.63	0.002	1.5	1	0.019	0.021
16	8	11.31	0.003	1.5	1	0.019	0.024
8	4	5.66	0.007	1.5	1	0.019	0.029
4	2	2.83	0.013	1.5	1	0.019	0.039
2	1	1.41	0.026	1.5	1	0.019	0.058
1	0.5	0.71	0.052	1.5	1	0.019	0.097

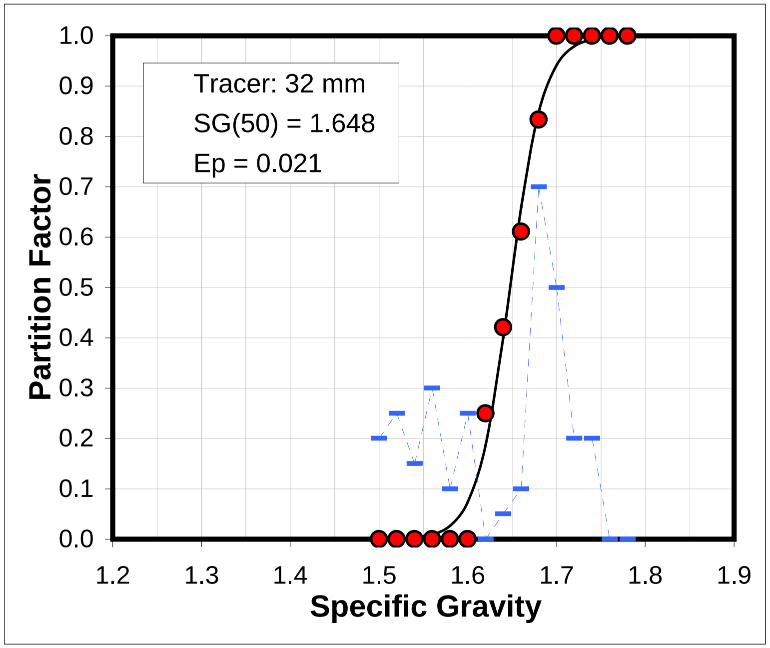
Comments: Unit B retained tracers from 1.66-1.70 SG

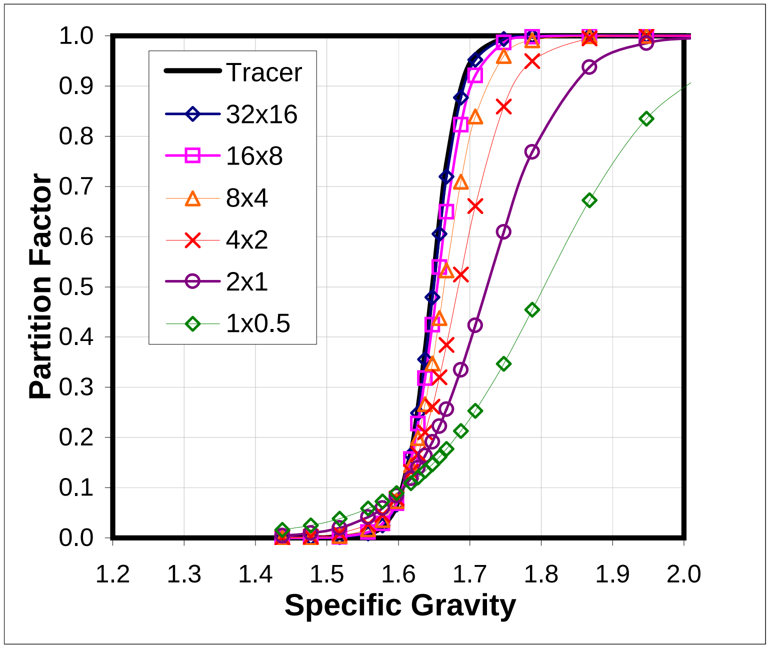
	SG	Split
O/F:	1.385	0.903
U/F:	1.850	0.097
Feed:	1.430	1.000

	SG	Split
Pivot:	1.606	0.097
O/F-U/F	0.47	HIGH!

Obs.	Marcy Scale SG Feed	O/F	U/F
1	1.43	1.39	1.85
2		1.38	
3			
4			
5			
Avg.	1.430	1.385	1.850

Size	32	32x16	16x8	8x4	4x2	2x1	1x0.5
SG(50)	1.648	1.649	1.654	1.664	1.684	1.724	1.804
Ep	0.021	0.021	0.024	0.029	0.039	0.058	0.10
Offset	0.000	0.000	0.000	0.000	0.000	0.000	0.000





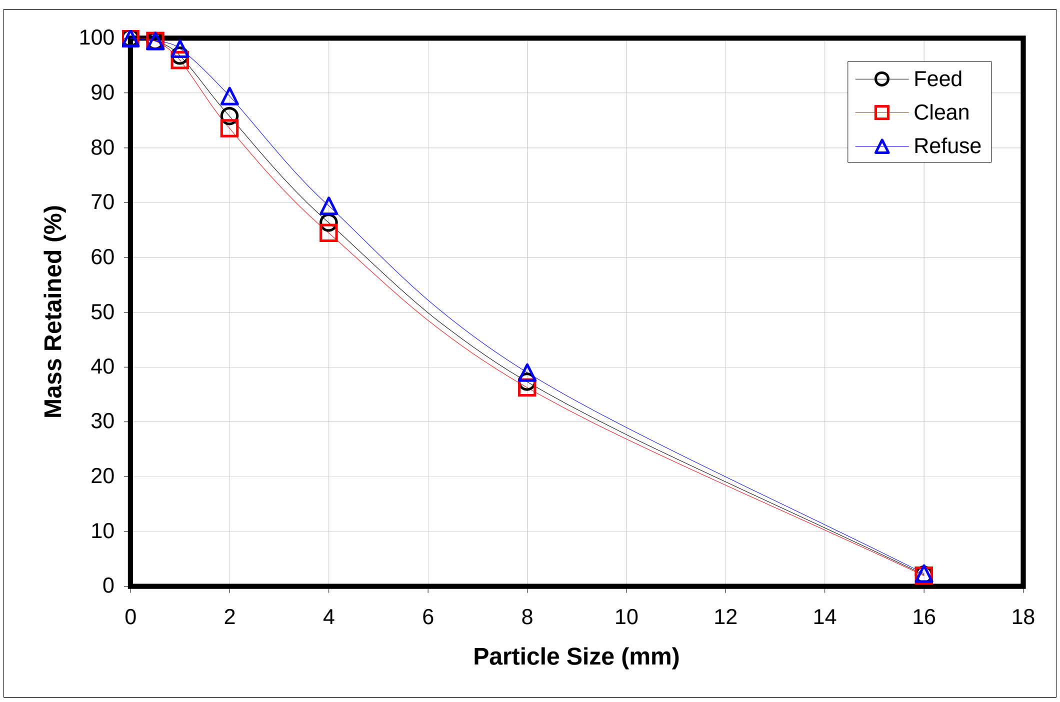
Note: Dashed line represents lost tracers.

Circuit: CIRCUIT E - COARSE COAL HMC CIRCUIT

Clean Rate (t/hr):	139.4		Clean Yield (%):	61.96
Refuse Rate (t/hr):	85.6		Refuse Yield (%):	38.04
Feed Rate (t/hr):	225.0			

Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Mass (%)	Clean Ash (%)	Refuse Mass (%)	Refuse Ash (%)	Feed Mass (%)	Feed Ash (%)
32	16	22.63	1.94	13.51	2.34	71.17	2.09	38.01
16	8	11.31	34.31	12.13	36.63	70.60	35.19	35.28
8	4	5.66	28.19	11.32	30.45	71.67	29.05	35.39
4	2	2.83	19.09	10.96	19.98	73.10	19.43	35.27
2	1	1.41	12.47	11.24	8.66	74.97	11.02	30.30
1	0.5	0.71	3.47	12.50	1.44	76.87	2.70	25.54
0.5	0.001	0.02	0.53	19.34	0.50	77.43	0.52	40.55
		Totals	100.00	11.65	100.00	71.94	100.00	34.58

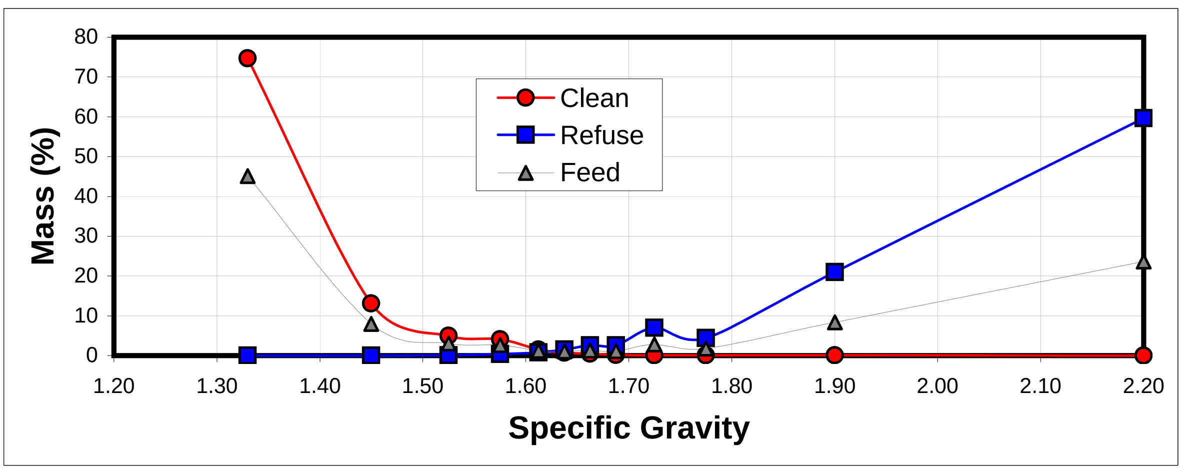
Pass Size (mm)	Retain Size (mm)	Mean Size (mm)	Clean Yield (%)	Refuse Yield (%)	Feed Yield (%)	Clean Mass (Cum%)	Refuse Mass (Cum%)	Feed Mass (Cum%)
32	16	22.63	57.52	42.48	100.00	1.94	2.34	2.09
16	8	11.31	60.40	39.60	100.00	36.25	38.97	37.28
8	4	5.66	60.12	39.88	100.00	64.44	69.42	66.33
4	2	2.83	60.88	39.12	100.00	83.53	89.40	85.77
2	1	1.41	70.10	29.90	100.00	96.00	98.07	96.78
1	0.5	0.71	79.74	20.26	100.00	99.47	99.50	99.48
0.5	0.001	0.02	63.49	36.51	100.00	100.00	100.00	100.00
		Totals	61.96	38.04	100.00			

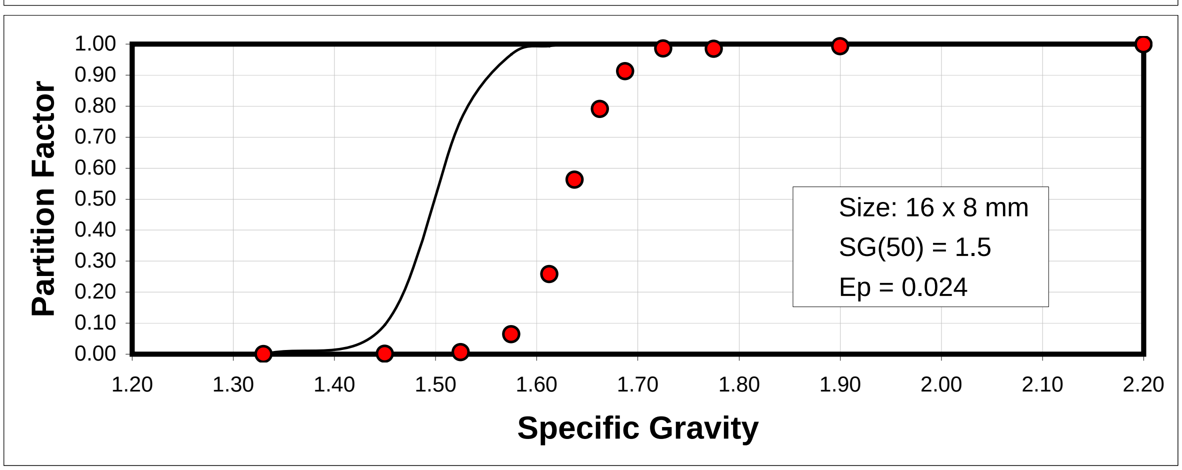


Circuit:	CIRCUIT E - COARSE COAL HMC CIRCUIT
Size:	16 x 8 mm

Clean Yield (%)	60.40	SG Cutpoint (SG50)	1.500	Weighting (Y/N)?	Y
Refuse Yield (%)	39.60	Probable Error (Ep):	0.024	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	74.67	0.01	45.10	0.00	0.00	0.10	0.00
1.400	1.500	1.450	13.13	0.02	7.94	0.00	0.09	0.10	0.88
1.500	1.550	1.525	4.96	0.05	3.02	0.01	0.76	0.10	56.14
1.550	1.600	1.575	4.11	0.43	2.65	0.06	0.97	0.10	81.58
1.600	1.625	1.613	1.50	0.79	1.22	0.26	0.99	0.26	8.11
1.625	1.650	1.638	0.76	1.50	1.05	0.56	1.00	0.44	0.99
1.650	1.675	1.663	0.45	2.58	1.29	0.79	1.00	0.21	0.99
1.675	1.700	1.688	0.16	2.58	1.12	0.91	1.00	0.10	0.77
1.700	1.750	1.725	0.07	6.97	2.80	0.99	1.00	0.10	0.02
1.750	1.800	1.775	0.04	4.44	1.79	0.98	1.00	0.10	0.02
1.800	2.000	1.900	0.11	20.95	8.36	0.99	1.00	0.10	0.01
2.000	2.400	2.200	0.04	59.68	23.65	1.00	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	149.51

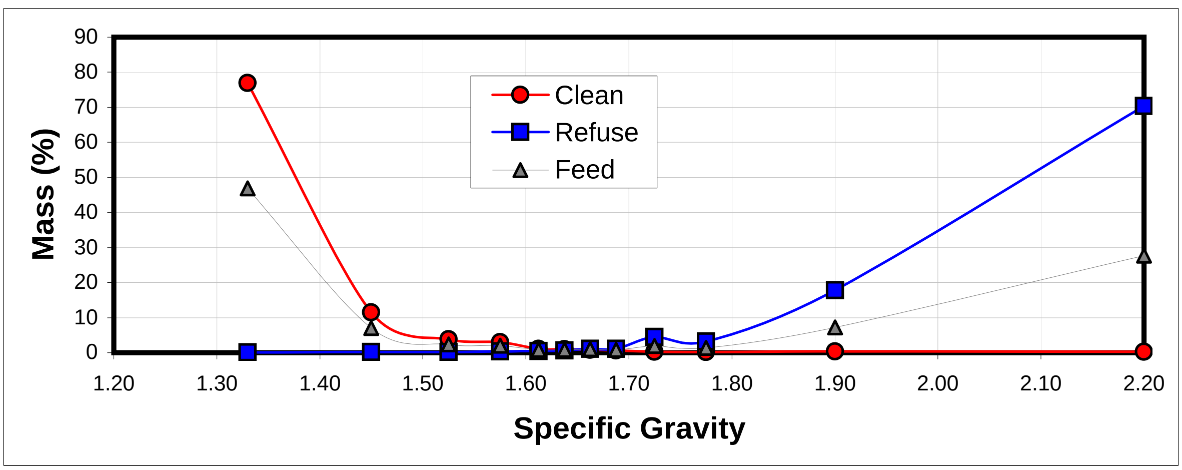


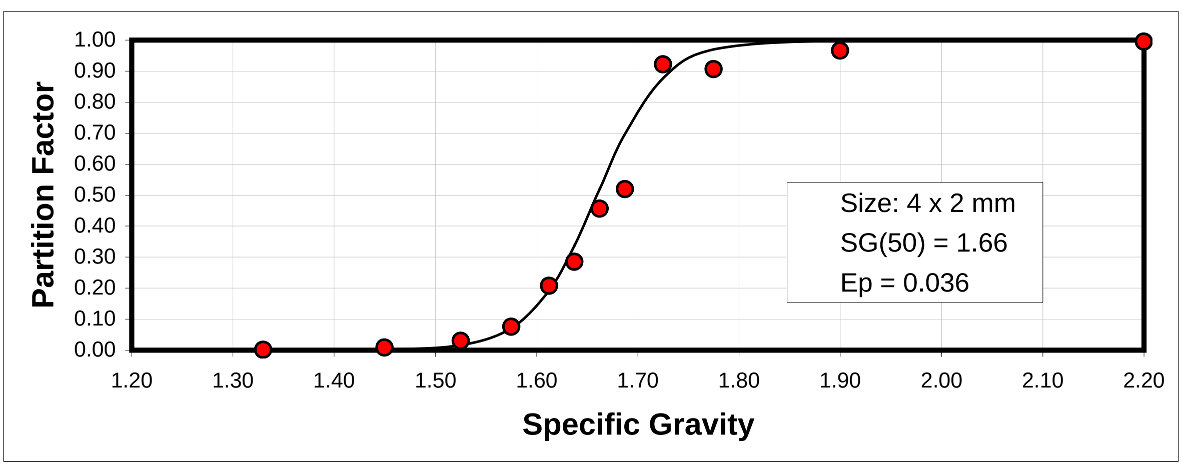


Circuit:	CIRCUIT E - COARSE COAL HMC CIRCUIT
Size:	4 x 2 mm

Clean Yield (%)	60.88	SG Cutpoint (SG50)	1.660	Weighting (Y/N)?	Y
Refuse Yield (%)	39.12	Probable Error (Ep):	0.036	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.400	1.330	76.95	0.13	46.90	0.00	0.00	0.10	0.00
1.400	1.500	1.450	11.51	0.14	7.06	0.01	0.00	0.10	0.00
1.500	1.550	1.525	3.82	0.18	2.40	0.03	0.02	0.10	0.02
1.550	1.600	1.575	3.04	0.38	2.00	0.07	0.07	0.10	0.00
1.600	1.625	1.613	1.05	0.43	0.81	0.21	0.19	0.21	0.00
1.625	1.650	1.638	0.97	0.60	0.82	0.28	0.34	0.28	0.03
1.650	1.675	1.663	0.87	1.13	0.97	0.46	0.52	0.46	0.02
1.675	1.700	1.688	0.68	1.14	0.86	0.52	0.70	0.48	0.14
1.700	1.750	1.725	0.24	4.47	1.90	0.92	0.88	0.10	0.19
1.750	1.800	1.775	0.21	3.23	1.39	0.91	0.97	0.10	0.40
1.800	2.000	1.900	0.40	17.83	7.22	0.97	1.00	0.10	0.11
2.000	2.400	2.200	0.26	70.34	27.67	0.99	1.00	0.10	0.00
		Totals	100.00	100.00	100.00			WSSQ:	0.93

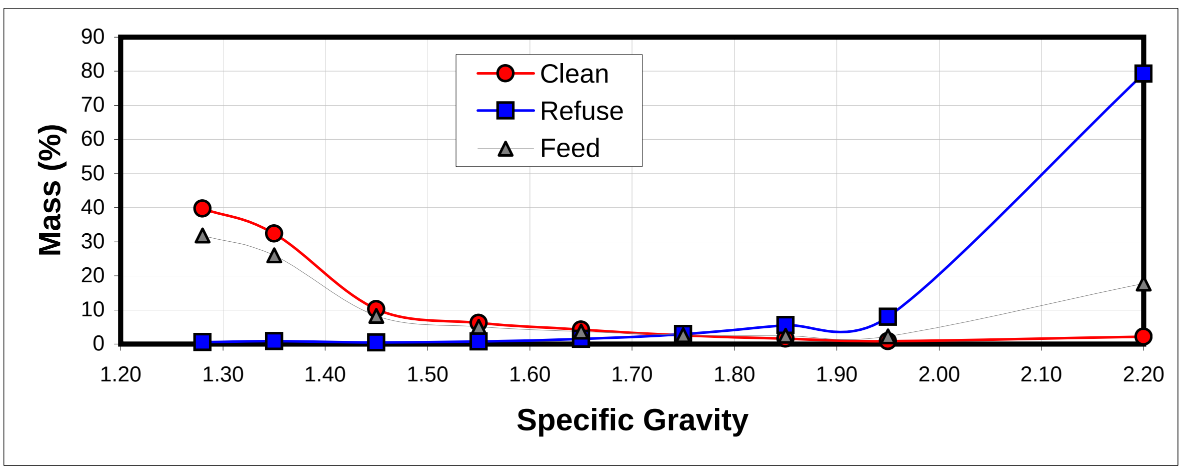


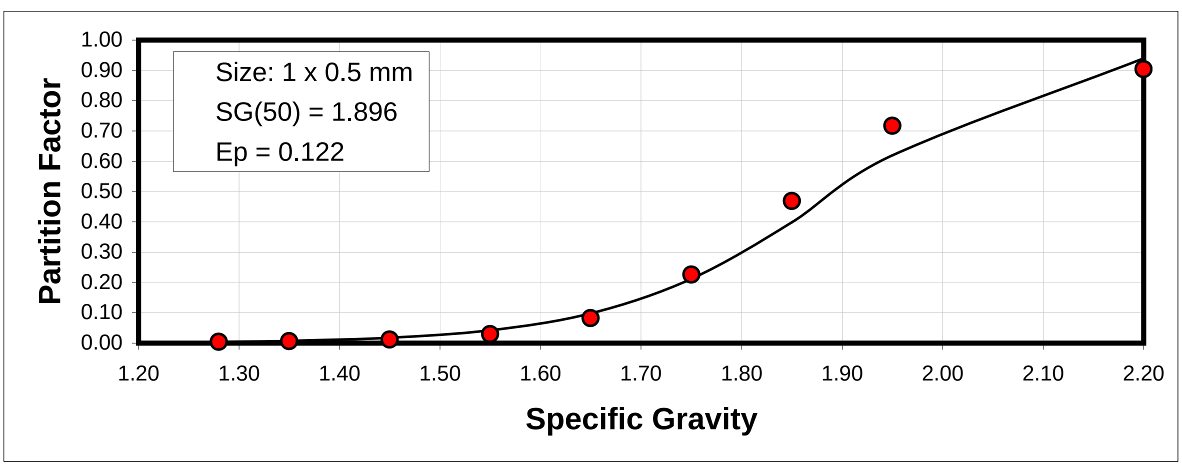


Circuit:	CIRCUIT E - COARSE COAL HMC CIRCUIT
Size:	1 x 0.5 mm

Clean Yield (%)	79.74	SG Cutpoint (SG50)	1.896	Weighting (Y/N)?	Y
Refuse Yield (%)	20.26	Probable Error (Ep):	0.122	Low SG Offset:	0.00

Sink SG	Float SG	Mean SG	Clean Mass (% Strm)	Refuse Mass (% Strm)	Feed Mass (% Strm)	Measured Refuse Partition	Fitted Refuse Partition	Fitting Weight Factor	Weighted Squared Error
1.260	1.300	1.280	39.77	0.58	31.83	0.00	0.00	0.10	0.00
1.300	1.400	1.350	32.45	0.88	26.06	0.01	0.01	0.10	0.00
1.400	1.500	1.450	10.27	0.49	8.28	0.01	0.02	0.10	0.00
1.500	1.600	1.550	6.17	0.75	5.08	0.03	0.04	0.10	0.02
1.600	1.700	1.650	4.25	1.51	3.70	0.08	0.10	0.10	0.02
1.700	1.800	1.750	2.54	2.92	2.61	0.23	0.21	0.23	0.00
1.800	1.900	1.850	1.61	5.58	2.41	0.47	0.40	0.47	0.02
1.900	2.000	1.950	0.80	7.99	2.26	0.72	0.62	0.28	0.12
2.000	2.400	2.200	2.14	79.30	17.77	0.90	0.94	0.10	0.13
		Totals	100.00	100.00	100.00			WSSQ:	0.31

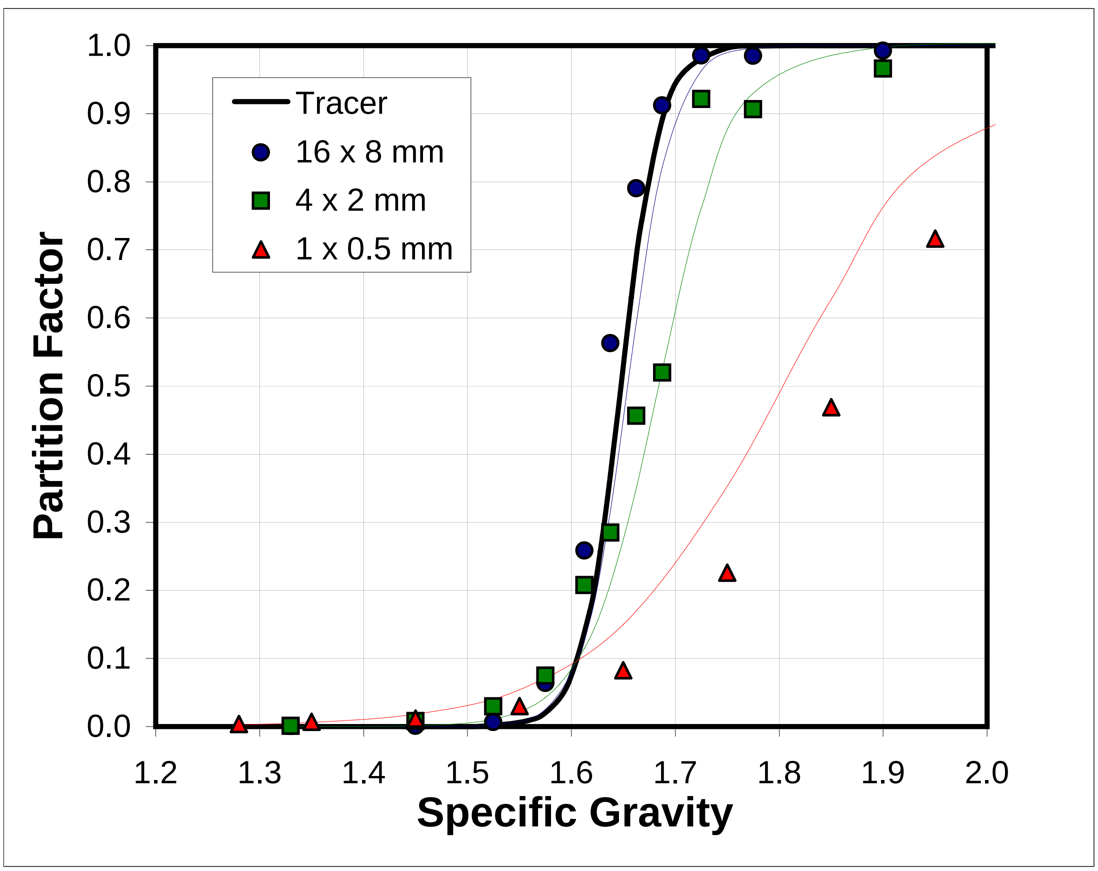


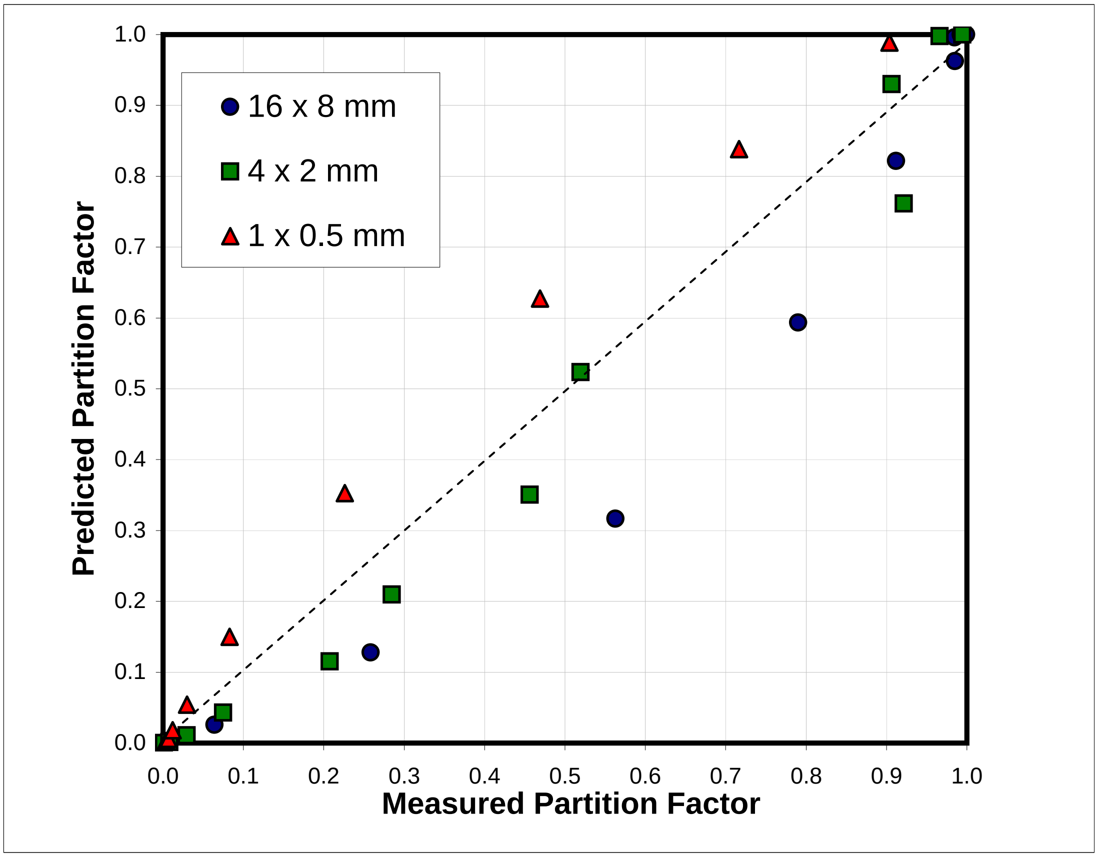


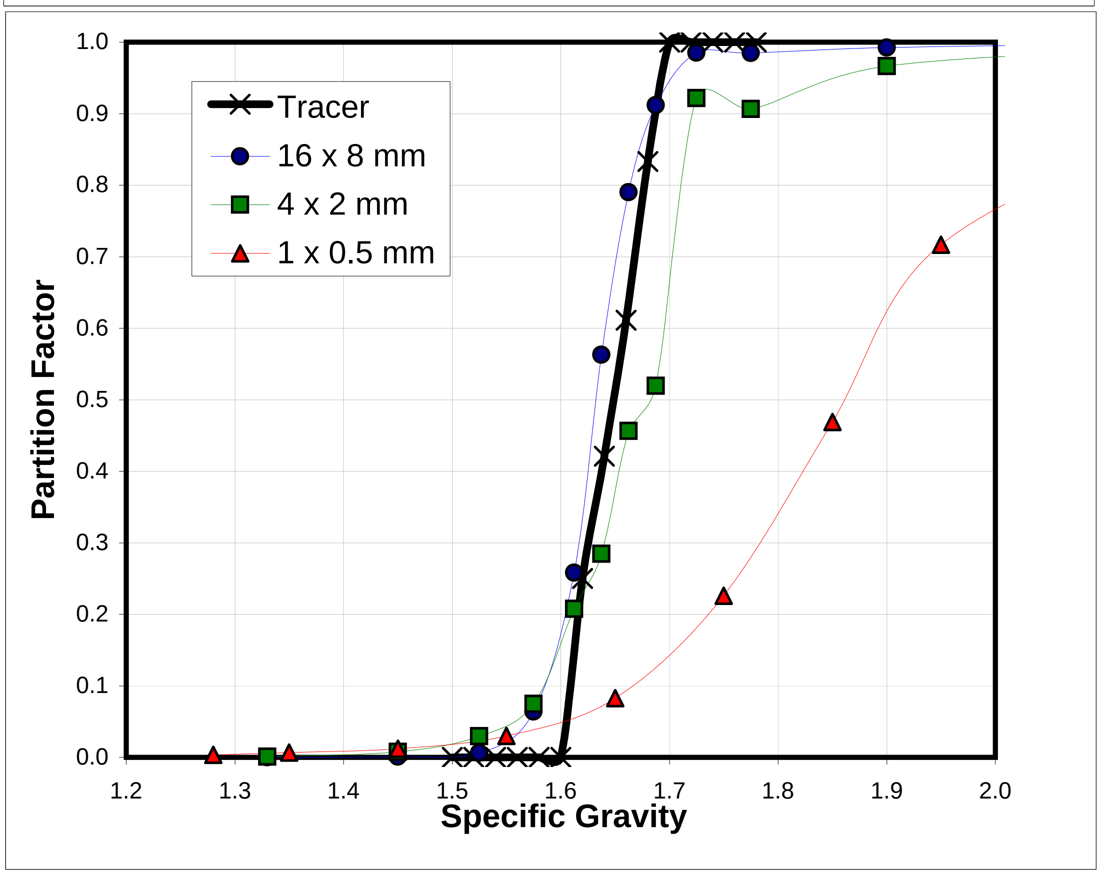
Circuit: CIRCUIT E - COARSE COAL HMC CIRCUIT

	Measured 16 x 8 mm	Predicted 16 x 8 mm		Measured 4 x 2 mm	Predicted 4 x 2 mm		Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
SG(50):	1.500	1.654	SG(50):	1.660	1.684	SG(50):	1.896	1.804
Ep:	0.024	0.024	Ep:	0.036	0.039	Ep:	0.122	0.097
Offset:	0.000	0.000	Offset:	0.000	0.000	Offset:	0.000	0.000

	U/F Partition Factor			U/F Partition Factor			U/F Partition Factor	
SG	Measured 16 x 8 mm	Predicted 16 x 8 mm	SG	Measured 4 x 2 mm	Predicted 4 x 2 mm	SG	Measured 1 x 0.5 mm	Predicted 1 x 0.5 mm
1.33	0.00	0.000	1.33	0.00	0.000	1.28	0.00	0.003
1.45	0.00	0.000	1.45	0.01	0.001	1.35	0.01	0.006
1.53	0.01	0.003	1.53	0.03	0.011	1.45	0.01	0.018
1.58	0.06	0.026	1.58	0.07	0.043	1.55	0.03	0.054
1.61	0.26	0.128	1.61	0.21	0.115	1.65	0.08	0.150
1.64	0.56	0.317	1.64	0.28	0.210	1.75	0.23	0.353
1.66	0.79	0.594	1.66	0.46	0.351	1.85	0.47	0.627
1.69	0.91	0.822	1.69	0.52	0.524	1.95	0.72	0.838
1.73	0.99	0.963	1.73	0.92	0.762	2.20	0.90	0.989
1.78	0.98	0.996	1.78	0.91	0.930			
1.90	0.99	1.000	1.90	0.97	0.998			
2.20	1.00	1.000	2.20	0.99	1.000			




16 x 8 mm
4 x 2 mm
1 x 0.5 mm
Predicted Partition Factor
Measured Partition Factor
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


Tracer
16 x 8 mm
4 x 2 mm
1 x 0.5 mm
Partition Factor
Specific Gravity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0

CIRCUIT E - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 1 of 4

Plant:	**PLANT E**		
ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	19,789	**Lab #:**	19,789
Weights	Grams	**Weights**	Grams
Flask	81.7474	**Flask**	78.2075
Flask, Non-Mag, Mags	96.8144	**Flask, Non-Mag, Mags**	93.8055
Flask + Mags	94.7251	**Flask + Mags**	91.6498
% Mags:	86.13%	**% Mags:**	86.18%

RUN AVG:	**86.16%**

ID:	**FEED MEDIA**	**ID:**	**FEED MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	19,790	**Lab #:**	19,790
Weights	Grams	**Weights**	Grams
Flask	68.4710	**Flask**	67.1409
Flask, Non-Mag, Mags	83.8132	**Flask, Non-Mag, Mags**	82.8614
Flask + Mags	81.6149	**Flask + Mags**	80.5134
% Mags:	85.67%	**% Mags:**	85.06%

RUN AVG:	**85.37%**
TOT AVG:	**85.76%**

CIRCUIT E - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 2 of 4

Plant:	**PLANT E**		
ID:	**CLEAN COAL #1 MEDIA**	**ID:**	**CLEAN COAL #1 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	19,791	**Lab #:**	19,791
Weights	Grams	**Weights**	Grams
Flask	63.5927	**Flask**	68.1780
Flask, Non-Mag, Mags	78.8126	**Flask, Non-Mag, Mags**	83.8172
Flask + Mags	76.6929	**Flask + Mags**	81.5979
% Mags:	86.07%	**% Mags:**	85.81%

RUN AVG:	**85.94%**

ID:	**CLEAN COAL #1 MEDIA**	**ID:**	**CLEAN COAL #1 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	19,792	**Lab #:**	19,792
Weights	Grams	**Weights**	Grams
Flask	68.3071	**Flask**	64.6433
Flask, Non-Mag, Mags	83.8158	**Flask, Non-Mag, Mags**	79.8267
Flask + Mags	81.5742	**Flask + Mags**	77.8063
% Mags:	85.55%	**% Mags:**	86.69%

RUN AVG:	**86.12%**

TOT AVG:	**86.03%**

CIRCUIT E - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 3 of 4

Plant:	**PLANT E**		
ID:	**CLEAN COAL #2 MEDIA**	**ID:**	**CLEAN COAL #2 MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	19,793	**Lab #:**	19,793
Weights	Grams	**Weights**	Grams
Flask	67.4810	**Flask**	66.3531
Flask, Non-Mag, Mags	82.8134	**Flask, Non-Mag, Mags**	81.8163
Flask + Mags	80.5946	**Flask + Mags**	79.6182
% Mags:	85.53%	**% Mags:**	85.78%

RUN AVG:	**85.66%**

ID:	**CLEAN COAL #2 MEDIA**	**ID:**	**CLEAN COAL #2 MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	19,794	**Lab #:**	19,794
Weights	Grams	**Weights**	Grams
Flask	68.4130	**Flask**	67.0916
Flask, Non-Mag, Mags	83.8161	**Flask, Non-Mag, Mags**	82.8215
Flask + Mags	81.6798	**Flask + Mags**	80.5746
% Mags:	86.13%	**% Mags:**	85.72%

RUN AVG:	**85.92%**
TOT AVG:	**85.79%**

CIRCUIT E - HMC PERFORMANCE TEST
MEDIA SAMPLES - PAGE 4 of 4

Plant:	**PLANT E**		
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	1-A	**Run:**	1-B
Lab #:	19,795	**Lab #:**	19,795
Weights	Grams	**Weights**	Grams
Flask	67.3686	**Flask**	63.8107
Flask, Non-Mag, Mags	82.8349	**Flask, Non-Mag, Mags**	78.8481
Flask + Mags	82.1382	**Flask + Mags**	78.1838
% Mags:	95.50%	**% Mags:**	95.58%
		RUN AVG:	**95.54%**
ID:	**REFUSE MEDIA**	**ID:**	**REFUSE MEDIA**
Run:	2-A	**Run:**	2-B
Lab #:	19,796	**Lab #:**	19,796
Weights	Grams	**Weights**	Grams
Flask	68.0946	**Flask**	68.0054
Flask, Non-Mag, Mags	83.8697	**Flask, Non-Mag, Mags**	83.8393
Flask + Mags	83.1089	**Flask + Mags**	83.0642
% Mags:	95.18%	**% Mags:**	95.10%
		RUN AVG:	**95.14%**
		TOT AVG:	**95.34%**

CIRCUIT E - HMC PERFORMANCE TEST
SAMPLE WEIGHTS & MOISTURE

**** ALL WEIGHTS IN GRAMS ****

SAMPLE ID	SCREEN NO.	BUCKET NO.	WET SAMPLE + CONTAINER	CONTAINER TARE	DRY SAMPLE + CONTAINER	WET SAMPLE WEIGHT	DRY SAMPLE WEIGHT
FEED	#1	1 OF 4	19,509.1	994.8	17,367.9	18,514.3	16,373.1
FEED	#1	2 OF 4	18,570.1	979.8	16,684.6	17,590.3	15,704.8
FEED	#1	3 OF 4	22,004.8	998.3	19,686.7	21,006.5	18,688.4
FEED	#1	4 OF 4	19,831.5	961.9	17,738.4	18,869.6	16,776.5
SUBTOTAL FEED	#1	4	79,915.5	3,934.8	71,477.6	75,980.7	67,542.8
FEED	#2	1 OF 4	17,336.7	1,000.3	15,776.9	16,336.4	14,776.6
FEED	#2	2 OF 4	16,875.7	945.5	15,246.3	15,930.2	14,300.8
FEED	#2	3 OF 4	21,309.0	928.0	19,182.4	20,381.0	18,254.4
FEED	#2	4 OF 4	17,097.0	947.8	15,355.5	16,149.2	14,407.7
SUBTOTAL FEED	#2	4	72,618.4	3,821.6	65,561.1	68,796.8	61,739.5
TOTAL FEED	#1 & #2	8	152,533.9	7,756.4	137,038.7	144,777.5	129,282.3
CLEAN COAL	#1	1 OF 4	14,881.8	912.6	13,199.1	13,969.2	12,286.5
CLEAN COAL	#1	2 OF 4	19,759.4	922.8	17,273.4	18,836.6	16,350.6
CLEAN COAL	#1	3 OF 4	16,266.7	992.2	14,536.5	15,274.5	13,544.3
CLEAN COAL	#1	4 OF 4	19,058.3	914.1	16,620.6	18,144.2	15,706.5
SUBTOTAL CC	#1	4	69,966.2	3,741.7	61,629.6	66,224.5	57,887.9
CLEAN COAL	#2	1 OF 4	16,174.5	993.7	14,232.9	15,180.8	13,239.2
CLEAN COAL	#2	2 OF 4	14,020.9	998.3	12,208.0	13,022.6	11,209.7
CLEAN COAL	#2	3 OF 4	15,833.0	986.5	13,850.1	14,846.5	12,863.6
CLEAN COAL	#2	4 OF 4	15,301.8	998.3	13,334.5	14,303.5	12,336.2
SUBTOTAL CC	#2	4	61,330.2	3,976.8	53,625.5	57,353.4	49,648.7
TOTAL CC	#1 & #2	8	131,296.4	7,718.5	115,255.1	123,577.9	107,536.6
REFUSE	#1	1 OF 8	19,862.9	985.8	18,491.9	18,877.1	17,506.1
REFUSE	#1	2 OF 8	21,053.4	915.2	19,722.6	20,138.2	18,807.4
REFUSE	#1	3 OF 8	14,154.0	1,011.1	13,331.9	13,142.9	12,320.8
REFUSE	#1	4 OF 8	19,707.3	922.9	18,461.0	18,784.4	17,538.1
REFUSE	#1	5 OF 8	12,584.5	993.3	11,816.6	11,591.2	10,823.3
REFUSE	#1	6 OF 8	16,585.1	996.4	15,497.9	15,588.7	14,501.5
REFUSE	#1	7 OF 8	13,091.1	1,020.7	12,282.9	12,070.4	11,262.2
REFUSE	#1	8 OF 8	22,756.7	1,046.4	21,059.2	21,710.3	20,012.8
TOTAL REF	#1	8	139,795.0	7,891.8	130,664.0	131,903.2	122,772.2

CIRCUIT E - HMC PERFORMANCE TEST
MEDIA SAMPLES

FEED MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	12,855.1	TARE WT.	961.4
SOLIDS WT.	5,886.1	% SOLIDS	49.49%
LAB NO.	SIZE	WT (Grams)	WT %
16,067	+ 25M	1,736.2	29.50%
16,068	25M x 0	4,149.9	70.50%
	Totals	5,886.1	100.00%

CLEAN COAL #1 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,831.5	TARE WT.	417.7
SOLIDS WT.	1,666.5	% SOLIDS	37.76%
LAB NO.	SIZE	WT (Grams)	WT %
16,069	+ 25M	86.2	5.17%
16,070	25M x 0	1,580.3	94.83%
	Totals	1,666.5	100.00%

CLEAN COAL #2 MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,503.8	TARE WT.	422.4
SOLIDS WT.	1,537.1	% SOLIDS	37.66%
LAB NO.	SIZE	WT (Grams)	WT %
16,071	+ 25M	55.8	3.63%
16,072	25M x 0	1,481.3	96.37%
	Totals	1,537.1	100.00%

REFUSE MEDIA			
NOTE: WET SCREEN ENTIRE SAMPLE (25M = 710 microns) HOLD ALL DRY SPLITS FOR FURTHER INSTRUCTION			
TOTAL WT.	4,052.0	TARE WT.	414.5
SOLIDS WT.	2,092.8	% SOLIDS	57.53%
LAB NO.	SIZE	WT (Grams)	WT %
16,073	+ 25M	11.6	0.55%
16,074	25M x 0	2,081.2	99.45%
	Totals	2,092.8	100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE - SCREEN ANALYSIS

Combine all eight (8) clean coal samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	107,536.6	Grams or	237.078	Lbs
START WEIGHT - REWEIGH:	237.00	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
22,802	11.38

Screen Analysis (Using 7 Containers) 208.0 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
22,803	+ 16mm	1,827.6	Grams	1.94%	13.51
22,804	*16 x 8mm*	32,295.8	Grams	34.31%	12.13
22,805	8 x 4mm	26,535.2	Grams	28.19%	11.32
Totals	+4mm	60,658.6	Grams	64.44%	11.82

Total +4mm Wt	60,658.6	Grams	64.44%			
Total -4mm Wt	33,475.1	Grams	35.56%			
Total Wt	94,133.7	Grams	100.00%	or	207.5	Lbs
Screen Loss	213.5	Grams		or	0.23	%
-4mm Split Wt	33,475.1	Grams	(Use All)			
Screen Loss	132.1	Grams		or	0.39	%
Total Scr Loss	345.6	Grams		or	0.37	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
22,806	*4 x 2mm*	17,901.9	Grams	19.09%	10.96
22,807	2 x 1mm	11,687.8	Grams	12.47%	11.24
22,808	*1 x 0.5mm*	3,254.9	Grams	3.47%	12.50
22,809	0.5mm x 0	498.4	Grams	0.53%	19.34
Totals	4mm x 0	33,343.0	Grams	35.56%	11.33
Totals	+16mm x 0	94,001.6	Grams	100.00%	11.65

CIRCUIT E - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	24,048.3	Grams			
LOSS:	50.4	Grams	or	0.21	%

LAB #	GRAVITY	WT	Units	WT%
24,339	1.400	17,918.7	Grams	74.67%
24,340	1.500	3,151.7	Grams	13.13%
24,341	1.550	1,191.3	Grams	4.96%
24,342	1.600	985.4	Grams	4.11%
24,343	1.625	359.1	Grams	1.50%
24,344	1.650	183.1	Grams	0.76%
24,345	1.675	107.8	Grams	0.45%
24,346	1.700	39.2	Grams	0.16%
24,347	1.750	16.4	Grams	0.07%
24,348	1.800	10.7	Grams	0.04%
24,349	2.000	25.6	Grams	0.11%
24,350	SINK	8.9	Grams	0.04%
TOTAL		23,997.9		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	13,363.3	Grams			
LOSS:	18.7	Grams	or	0.14	%

LAB #	GRAVITY	WT	Units	WT%
25,552	1.400	10,268.5	Grams	76.95%
25,553	1.500	1,535.8	Grams	11.51%
25,554	1.550	510.3	Grams	3.82%
25,555	1.600	405.8	Grams	3.04%
25,556	1.625	140.6	Grams	1.05%
25,557	1.650	128.9	Grams	0.97%
25,558	1.675	115.7	Grams	0.87%
25,559	1.700	90.3	Grams	0.68%
25,560	1.750	32.6	Grams	0.24%
25,561	1.800	28.5	Grams	0.21%
25,562	2.000	53.4	Grams	0.40%
25,563	SINK	34.2	Grams	0.26%
TOTAL		13,344.6		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC CLEAN COAL SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	2,435.8	Grams			
LOSS:	6.2	Grams	or	0.25	%

LAB #	GRAVITY	WT	Units	WT%
26,646	1.300	966.2	Grams	39.77%
26,647	1.400	788.5	Grams	32.45%
26,648	1.500	249.4	Grams	10.27%
26,649	1.600	150.0	Grams	6.17%
26,650	1.700	103.3	Grams	4.25%
26,651	1.800	61.6	Grams	2.54%
26,652	1.900	39.0	Grams	1.61%
26,653	2.000	19.5	Grams	0.80%
26,654	SINK	52.1	Grams	2.14%
TOTAL		2,429.6		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE - SCREEN ANALYSIS

Combine all eight (8) refuse samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	122,772.2	Grams or	270.666	Lbs
START WEIGHT - REWEIGH:	271.00	Lbs		

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
27,852	72.12

Screen Analysis (Using 7 Containers) 237.9 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
27,853	+ 16mm	2,519.1	Grams	2.34%	71.17
27,854	*16 x 8mm*	39,507.9	Grams	36.63%	70.60
27,855	8 x 4mm	32,840.1	Grams	30.45%	71.67
Totals	**+4mm**	**74,867.1**	**Grams**	**69.42%**	**71.09**

Total +4mm Wt	74,867.1	Grams	69.42%			
Total -4mm Wt	32,976.2	Grams	30.58%			
Total Wt	107,843.3	Grams	100.00%	or	237.8	Lbs
Screen Loss	66.3	Grams		or	0.06	%
-4mm Split Wt	32,976.2	Grams	(Use All)			
Screen Loss	236.9	Grams		or	0.72	%
Total Scr Loss	303.2	Grams		or	0.28	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
27,856	*4 x 2mm*	21,395.0	Grams	19.98%	73.10
27,857	2 x 1mm	9,273.4	Grams	8.66%	74.97
27,858	*1 x 0.5mm*	1,537.8	Grams	1.44%	76.87
27,859	0.5mm x 0	533.1	Grams	0.50%	77.43
Totals	**4mm x 0**	**32,739.3**	**Grams**	**30.58%**	**73.88**
Totals	**+16mm x 0**	**107,606.4**	**Grams**	**100.00%**	**71.94**

CIRCUIT E - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	29,540.9	Grams			
LOSS:	14.1	Grams	or	0.05	%

LAB #	GRAVITY	WT	Units	WT%
27,860	1.400	2.1	Grams	0.01%
27,861	1.500	5.2	Grams	0.02%
27,862	1.550	14.5	Grams	0.05%
27,863	1.600	126.7	Grams	0.43%
27,864	1.625	234.7	Grams	0.79%
27,865	1.650	442.6	Grams	1.50%
27,866	1.675	762.2	Grams	2.58%
27,867	1.700	762.7	Grams	2.58%
27,868	1.750	2,059.3	Grams	6.97%
27,869	1.800	1,311.4	Grams	4.44%
27,870	2.000	6,184.9	Grams	20.95%
27,871	SINK	17,620.5	Grams	59.68%
TOTAL		29,526.8		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	16,163.1	Grams			
LOSS:	43.5	Grams	or	0.27	%

LAB #	GRAVITY	WT	Units	WT%
29,267	1.400	21.3	Grams	0.13%
29,268	1.500	22.7	Grams	0.14%
29,269	1.550	29.3	Grams	0.18%
29,270	1.600	61.8	Grams	0.38%
29,271	1.625	69.2	Grams	0.43%
29,272	1.650	96.4	Grams	0.60%
29,273	1.675	182.5	Grams	1.13%
29,274	1.700	183.6	Grams	1.14%
29,275	1.750	720.7	Grams	4.47%
29,276	1.800	519.9	Grams	3.23%
29,277	2.000	2,873.4	Grams	17.83%
29,278	SINK	11,338.8	Grams	70.34%
TOTAL		16,119.6		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC REFUSE SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	1,148.4	Grams			
LOSS:	3.1	Grams	or	0.27	%

LAB #	GRAVITY	WT	Units	WT%
29,717	1.300	6.7	Grams	0.58%
29,718	1.400	10.1	Grams	0.88%
29,719	1.500	5.6	Grams	0.49%
29,720	1.600	8.6	Grams	0.75%
29,721	1.700	17.3	Grams	1.51%
29,722	1.800	33.4	Grams	2.92%
29,723	1.900	63.9	Grams	5.58%
29,724	2.000	91.5	Grams	7.99%
29,725	SINK	908.2	Grams	79.30%
TOTAL		1,145.3		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC FEED SAMPLE - SCREEN ANALYSIS

Combine all eight (8) feed samples into one (1) sample

Note: Perform duplicate runs for ash determinations

COMPOSITE DRY WEIGHT:	129,282.3	Grams or	285.019	Lbs
START WEIGHT - REWEIGH:	285.00		Lbs	

Sub-divide sample using rotary divider: Hold 7 containers for screen analysis and use 1 container for head ash.

Head Ash

Lab #	Dry Ash
17,846	35.06

Screen Analysis (Using 7 Containers) 250.2 Lbs

Note: Isolate 25% of Each Screen Size Fraction for Head Ash

Hold 75% of Each Screen Size Fraction for Float & Sink

DRY SCREEN USING GILSON

Lab #	Size	Wt.	Units	Wt. %	Ash
17,847	+ 16mm	2,086.5	Grams	1.85%	36.16
17,848	*16 x 8mm*	34,835.9	Grams	30.83%	35.93
17,849	8 x 4mm	32,069.0	Grams	28.38%	34.89
Totals	+4mm	68,991.4	Grams	61.06%	35.45

Total +4mm Wt	68,991.4	Grams	61.06%			
Total -4mm Wt	43,996.5	Grams	38.94%			
Total Wt	112,987.9	Grams	100.00%	or	249.1	Lbs
Screen Loss	500.9	Grams		or	0.44	%
-4mm Split Wt	43,996.5	Grams	(Use All)			
Screen Loss	195.3	Grams		or	0.44	%
Total Scr Loss	696.2	Grams		or	0.61	%

WET SCREENING USING 12" SIEVES

Lab #	Size	Wt.	Units	Wt. %	Ash
17,850	*4 x 2mm*	22,576.2	Grams	20.07%	35.17
17,851	2 x 1mm	14,262.7	Grams	12.68%	35.54
17,852	*1 x 0.5mm*	4,932.3	Grams	4.38%	37.07
17,853	0.5mm x 0	2,030.0	Grams	1.80%	44.78
Totals	4mm x 0	43,801.2	Grams	38.94%	35.95
Totals	+16mm x 0	112,792.6	Grams	100.00%	35.65

CIRCUIT E - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	16 x 8mm				
START WT:	26,108.9	Grams			
LOSS:	83.2	Grams	or	0.32	%

LAB #	GRAVITY	WT	Units	WT%
17,854	1.400	10,756.4	Grams	41.33%
17,855	1.500	2,009.4	Grams	7.72%
17,856	1.550	761.1	Grams	2.92%
17,857	1.600	625.3	Grams	2.40%
17,858	1.625	543.4	Grams	2.09%
17,859	1.650	354.0	Grams	1.36%
17,860	1.675	272.8	Grams	1.05%
17,861	1.700	424.5	Grams	1.63%
17,862	1.750	712.5	Grams	2.74%
17,863	1.800	792.0	Grams	3.04%
17,864	2.000	2,053.1	Grams	7.89%
17,865	SINK	6,721.2	Grams	25.83%
TOTAL		26,025.7		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	4 x 2mm				
START WT:	16,890.8	Grams			
LOSS:	33.7	Grams	or	0.20	%

LAB #	GRAVITY	WT	Units	WT%
18,634	1.400	7,600.3	Grams	45.09%
18,635	1.500	1,209.9	Grams	7.18%
18,636	1.550	517.8	Grams	3.07%
18,637	1.600	214.6	Grams	1.27%
18,638	1.625	169.6	Grams	1.01%
18,639	1.650	143.0	Grams	0.85%
18,640	1.675	224.9	Grams	1.33%
18,641	1.700	277.9	Grams	1.65%
18,642	1.750	305.8	Grams	1.81%
18,643	1.800	310.2	Grams	1.84%
18,644	2.000	1,146.6	Grams	6.80%
18,645	SINK	4,736.5	Grams	28.10%
TOTAL		16,857.1		100.00%

CIRCUIT E - HMC PERFORMANCE TEST

HMC FEED SAMPLE

FLOAT & SINK ANALYSIS

SIZE:	1 x 0.5mm				
START WT:	3,735.2	Grams			
LOSS:	0.3	Grams	or	0.01	%

LAB #	GRAVITY	WT	Units	WT%
18,646	1.300	1,125.7	Grams	30.14%
18,647	1.400	548.3	Grams	14.68%
18,648	1.500	257.4	Grams	6.89%
18,649	1.600	150.6	Grams	4.03%
18,650	1.700	124.8	Grams	3.34%
18,651	1.800	103.3	Grams	2.77%
18,652	1.900	116.6	Grams	3.12%
18,653	2.000	128.3	Grams	3.44%
18,654	SINK	1,179.9	Grams	31.59%
TOTAL		3,734.9		100.00%